CANADA

IDRC-TS31e

Science and Technology for Development

Technical Changes in Industrial Branches

STPI Module 10

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for Development

STPI MODULE 10: TECHNICAL CHANGES IN INDUSTRIAL BRANCHES

F. Sercovich

CONTENTS

FOREWORD

This module constitutes an integral part of the Main Comparative Report of the Science and Technology Policy Instruments (STPI) project, a large research effort that examines the design and implementation of science and technology policies in 10 developing countries (Appendixes 1 and 2).

The STPI project generated a large number of reports, essays, and monographs covering a great variety of themes in science and technology for development. More than 250 documents were produced by the country teams and the Field Coordinator's Office, and this proliferation posed rather difficult problems during the comparative phase of the project. It was decided that a Main Comparative Report, covering the substantive aspects of the research work of the country teams would be published, and that several monographs treating specific subjects would complement it.

The Main Comparative Report is organized in three parts. The first consists of a short essay covering the main policy and research issues identified through the research, and the second contains the most relevant results of a comparative nature that were obtained in the project. These first two parts have been published by the International Development Research Centre in a single volume in English, Spanish, and French (109e, 109s, and 109f).

The third part of the Main Comparative Report consists of 12 modules containing material selected from the many reports produced during the STPI project. They provide the supporting material for the findings described and the assertions made in the first two parts of the Main Comparative Report.

The modules were prepared by several consultants, and given the diversity of topics covered, the IDRC staff did not consider it desirable nor possible to impose a single format or structure for their preparation. The reader will find a diversity of styles and structures in the modules and will find that the selection of texts reflects the views of the consultant who compiled the module. However, the modules were prepared in close collaboration with the Field Coordinator and were also submitted to a STPI editorial committee who ensured that they provided a representative sample of STPI material. They should be read in conjunction with the first two parts of the Main Comparative Report.

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INTRODUCTION

The material in this module examines the patterns of technical change at the industrial branch level, focusing on the impact of certain key policy instruments and related factors. These studies represent the highest level of aggregation found in the STPI reports on technical change, and highlight the structural factors at the level of industrial branches that affect the development of local S&T capabilities.

The five case studies included in the module cover the machine tools industry (Argentina and Brazil), the powder metallurgy industry (Korea), the electronics industry (India), and the capital goods industries in general (Venezuela).

ARGENTINA

(The Machine Tools Industry)

Introduction

This section attempts to analyze the set of elements that make up the framework within which the entrepreneurs of the machine tools sector make their technological decisions; in addition, an effort is made to gain some knowledge of the characteristics of these decisions. The starting hypothesis is that technological decisions are the result of a complex of interactions, in which the following elements intervene: (a) the general characteristics of the sector's insertion within the structure and dynamics of the economy; (b) the production structure of the sector itself; (c) the firm's own characteristics, distinguishing within them those corresponding to: (1) economic variables, (2) technological capability, (3) management capability; (d) the environment of technological support, particularly the agencies of creation, extension, and information; and (e) certain sociological characteristics of the entrepreneurs of the sector, considered both individually and as a group.

History

The history of the machine tools sector starts at the beginning of this century, when in 1906 the first machines were manufactured in Argentina.

It originated mainly, as did most capital goods industries, in the process of repairing imported equipment, and grew as the difficulties for importing increased, albeit disjointedly and not integrated as a true industry.

Because the pioneering firms were repair shops rather than true factories, they had to confront the strong imports of the first decades (from 1920 on), which acted as a factor hindering their growth. Inasmuch as it was impossible to compete with the imported machines because of their better quality, tradition, and price, many firms had to close down.

During World War II, a period during which imports were not allowed, the "unavoidable protectionism" again encouraged national industry, and in the 1940s and the beginning of the 1950s all the large firms of the sector got settled. Once the War was over, the Argentinian market reinitiated its external trade, importing machine tools mainly from the United States and Europe. Those machines were of a type similar to the ones then produced in the country, but of better quality, which put the newly settled firms at the brink of collapse.

In the mid-1950s the national factories started to strengthen their positions as producers, with imported production equipment that improved the quality of the national products and the deteriorated image the buyers had of them. This strengthening finally became effective at the beginning of the 1960s, when, because of the need to rely on a real machine tools industry capable of offering the elements necessary for the new model of industrial development that was being prepared in the country, attention began to be paid to the fact that to assure development of the sector, it was necessary to grant sufficient custom protection. The early birth of the sector is also reflected in the average age of the firms at present, as is shown in Table 1. Over 70% of the firms have an average age of 10 years or more, which is particularly significant if one considers the type of activity developed - metalworking - for which experience is a prerequisite for the possibilities of innovation.

Size

According to the personnel employed, the firms in this sector may be classified into: large, i.e., employing over 45 workers; medium, i.e., with a labour force of 20-45 people; small, i.e., having 6-19 workers; and very small, i.e., factories having up to 5 workers.

This distribution by size categories shows that the small and very small firms represent 65.9% of the machine tools sector and produce 56.3% of the units, which represents 19.4% of the production value of the sector (see Table 2).

This implies that the machine tools industry, like the majority of national industries, is fairly atomized in the lower strata, with a high number of units produced but with little relevance in terms of values - approximately $500 per unit. This also shows the scarce technological sophistication of this type of good.

In the medium-size category, distribution is more balanced, for it includes 21.3% of the firms and 31% of the units produced. Since its production value reaches 26.8% of the total, one can infer that the goods have greater technological sophistication than those of the small and very small categories.

The imbalance as regards technology is clearly seen with the large firms, for in this category 12.8% of the firms produce 53.8% of the total production value. Broken down by types of machines, they represent 62% of the total of lathes, 64% of the milling machines, 85.4% of the benders, and 46.1% of the working beams (to cite only the main products). But in numbers of units, they constitute only 12.7% of the total. The high average value of these machine tools, which approaches $7,000 per unit, points to the relatively high degree of technological sophistication that these products imply for the local market.

Concentration

One might refer to this sector as being highly concentrated in its higher stratum, in which 12.8% of the firms (from a total of 100 firms) possess 67% of the capital setup, 84% of the personnel employed in the industry, and the already mentioned 53.8% of the total production value. On the other hand, they have the largest capital-to-labour ratio - 9:4 - of the whole group, as measured by the average amount of fixed capital according to firm size over the average number of personnel employed also by size (for medium firms, this ratio is lower than the one for small firms).

Productive Structure

Because of both the degree of concentration described and the features inherent in the goods produced, which allow multiple differentiations, the productive structure of this sector appears to have the characteristics of a differentiated oligopoly.

Although one generally speaks of the machine tools sector as a whole, the machine tools are divided, depending on the type of work they perform, into two major categories: cutting and deformation. Within the first category are goods such as lathes, milling machines, boring machines, and drills. The second includes products such as presses, shears, benders, and working beams.

On the other hand, each good can be differentiated in terms of its size, functions, etc. The wide range of products and the diverse possibilities for manufacturing within each type of good account for the access to the market of both the small firms and the medium and large ones. They can come to the market inasmuch as their physical and technological capacities allow it, producing differentiations around basic models.

The large variety of goods and the technological differentiations within them are two factors that bring about a tacit distribution of the market among producers of the same type of good, which results in a highly imperfect market where competition does not take place through prices (within each stratum), but rather through subtle changes in design, dimensions, accessories, etc.

Domestic Market

According to a recent survey (1), 80% of the firms interviewed pointed to the automotive and automotive parts firms as their main consumers. Household appliances, shops, agricultural machinery, electromechanics, naval industry, railroads, etc., are in secondary positions; as a whole, they add up to over 40 industrial sectors.

Between the demand series analyzed and those of the machine tools there exists a certain coincidence in their cyclical movements, which is very significant in the case of the automotive industry and indicates a certain casual relationship between them. Also, coincident movements are recorded with tractors (agricultural machinery) and durable consumer goods.

These sectors clearly suffered a recession during 1966-1967, which affected the machine tools sector in a much more pronounced fashion. The high sensibility of this sector during periods when the consumers undergo crises is understood by considering the type of production in question; it is the barometer of the cyclical movements: the first to decay and the last to recover.

Tariff Protection

Under certain assumptions as to domestic vis-à-vis international prices, the current protection standard appears higher than that required to protect fully the domestic machine tools industry. This conclusion would also agree with results of the survey according to which the greatest percentage of those interviewed feel "adequately protected" by the tariff structure in force.

Business Cycle and Structure of Production

As a result of the continuous demand fluctuations that the machine tools industry must bear, with increasing difficulties in its production programs, reinvestment, finances, etc., a peculiar entrepreneurial behaviour has come about, characterized by the limited expansion of the supply of reproductive capacity. Furthermore, most firms work only a single shift, employing in almost all cases a surplus of labour after hours, but which does not get to exceed 40% of a shift, even when they have orders for up to 6 months of production.

This behaviour is also seen in the low specialization of the firms, as demonstrated by the fact that 45% of the sector's establishments develop other secondary activities alien to machine tools - although within the same metallurgical branch.

The production of machine tools during the period analyzed - 1961-1971 - denotes a twofold evolution. On the one hand, one notes a change in the relative participation of certain goods within the whole range produced, and on the other, one observes a greater technological sophistication in their manufacturing.

Technological Evolution

If one assumes that the existence of at least one engineer in the firm implies the possibility of reading, understanding, and interpreting technology with a scientific basis, the conclusion is reached that 40% of the firms surveyed would not be in the position to assimilate such knowledge and incorporate it into their technological evolution. These remarks, at least in the specific case of machine tools, must be considered in view of the direct observations done on the type of activities in which the engineers are employed. There would not be more than six firms among those surveyed in which there are what might be called white-collar engineers, that is, professionals whose immediate concerns (and even the physical working setting) are outside the everyday production problems, e.g., in a production and design department. In the remaining firms, the engineers perform roles related to problems that range from financial and commercial to quality control and collaboration in machine maintenance.

Three stages can be distinguished in the Argentinian machine tools industry. The first stage can be defined as the one in which the primary types of machine tools manufactured in the country appeared: lathes, milling machines, boring machines, working beams, etc. This stage started in Argentina with the birth of the activity at the beginning of this century and lasted until the end of the 1950s.

The second stage may be called the diversification one, and is characterized by the advent of diverse models starting from the basic types; they are differentiated among themselves in terms of their power, weight, speed, the addition of accessories that increase the operative possibilities, and the addition of modifications or minor improvements that - basically - make the machine operation easier. The modifications in the electrical, lubrication, and cooling systems, and the addition of brakes, clutches, etc., are included here.

In most cases, the technology involved in this stage was obtained through copying. Starting from both direct observation and the disassembly of imported machines, and even from leaflets and catalogues, the manufacturers of the sector, showing great mechanical skill, were producing and constantly diversifying their machines, with a high trial and error content in the process. If the type of technology used in this stage, in which one finds most firms, had to be characterized, one would say it is predominantly an artisan technology. These observations are consistent with the characteristics of the scarce existence and utilization of human resources at the university and technical level.

The incorporation of technological advancements that significantly improved the precision and durability features of the machines in this second stage was performed more slowly than the diversification of models and sizes and the incorporation of accessories. The diffusion of such advancements has remained limited to a reduced number of firms, some of which subsequently moved on to the third stage.

To try to confirm this hypothesis, those technological advancements have been listed in Table 3, specifying the year of their introduction, the innovating firms, and the firms that are currently using them. The characteristics of the firms that have adopted these advancements, i.e., large firms whose production represents a very important percentage of the total value, although reduced in numbers of machines, lead one to think that such advancements have been incorporated only into the machines of greater value, particularly those produced by three firms (A, B, C), while the bulk of national production is undertaken without these features.

The third stage, determined by the progressive evolution of the technological requirements of the automotive industry, is characterized by three types of elements: (a) the development of transfer and special machines that require a strong component of engineering creation, because of the specificity of the operations performed by each machine, as well as the precision requirements involved; (b) the advent of certain types of machines designed to perform works on large-size pieces with great versatility and precision; (c) the advent of machines equipped with partial and total automation schemes, and/or electronic instruments of measurement and control.

The grouping of machines with these three features in the same stage is due to the fact that all of them involve: (a) structure of creation and production that surpasses the artisan peculiarities of the vast majority of industry: engineers, updated technological information, precision control instruments; and (b) the entry of the Argentinian machine tools industry - though with a considerable time lag - in the predominant trends of countries with greater industrial development.

The advent of the machines included in this third stage came about at different times. The special and transfer machines appeared during the first half of the 1960s, with the birth of the automotive industry; they had great difficulties at the beginning, although after they were demanded by the large automotive firms they developed fast. The second type of machines appeared during the latter half of the 1960s, its ultimate expression being a production drill with 130 mm spindle, exhibited in the Sixth Argentinian Machine Tools Exposition (AMTE). The third type of machines, particularly electronic instruments of measurement and control, is just beginning to show its possibilities in the market. At the Sixth AMTE were two manufacturers who, in a process of evolution toward integral automation schemes through numerical control, exhibited digital control devices, with good acceptance on the part of most manufacturers, which certainly will modify the technological evolution patterns of the sector.

The firms that have come into this third stage show greater technological potential than the ones concretized in their present fulfillments, as is apparent from the observations of their project offices, quality control departments, and their technological evolution process during recent years. Limited by market considerations, by the company policy - in the case of a firm that is part of a wider whole that includes distribution - and even by fears about the future continuity of the firm, the companies leading the sector have progressed considerably less than would have been possible from their equipment and human capability. The data on the evolution of imports during recent years clearly show how the sector has been gradually falling behind the requirements of the most sophisticated demand.

Technological Support for the Sector

The technological evolution of the firms seems to be dependant almost exclusively on their own capacity. In other words, the relevant participation of people or agencies outside the firms who supported their technological evolution has not been detected.

Of the 23 firms surveyed, 17 (74%) never resorted to external consultants for the resolution of their technical problems. The six remaining firms did so only sporadically.

Concerning the state institutions that might have the mission of providing technological support for the sector, only the National Institute of Industrial Technology (INTI) can be mentioned. Eight of the firms surveyed stated they had on some occasion resorted to it. Those eight firms resorted to INTI only to order tests of materials and measurements, and in no case did they request technological information or support for designs, projects, problems in the machines' operation, etc.

The results of the relationship of these entrepreneurs with the Institute were in their judgement "negative" or "discouraging," due both to the delays in performing the jobs requested and to what the respondents judged as "excessive price" as compared with that charged by private test laboratories.

In summary, the deficiencies in applied research, development, transfer, and general technological support for the sector lead to a situation determined by each firm's capacity to rely on its own team of professionals or to attain through other means the technological support necessary for its evolution. But also, these deficiencies imply the absence of a supporting environment favourable to individual efforts toward technological development.

In view of the need for information, the government's instruments of financial, fiscal, and tariff promotion seem to become relative in terms of their effects, since they do not necessarily diminish the risk of innovation that is ultimately taken by the firms. The lack of information on the technological alternatives would thus limit the firm's decisions before the benefits offered by the instruments could be taken into account.

Circulation and Appropriability of the Technology

The characteristics of the technological evolution of the sector during the second stage - in which one finds most of the firms - can be directly related to the broad circulation of the technology incorporated in the machines and their consequently low degree of appropriability.

The history of the Machine Tools Expositions, which are organized every 2 years starting 12 years ago, shows the speed with which the minor innovations or improvements introduced by the manufacturers in their machines are diffused. Given the nature of the latter, direct observation and mechanical skill permit their easy incorporation.

In accordance with the latter, all the entrepreneurs agreed on the relative possibility of obtaining an exclusive exploitation of the improvements they achieved in their machines, questioning the usefulness of the patents as a protection system. In this regard, it can be mentioned that only eight of the 23 firms have registered patents. This fact may in principle be interpreted as resulting from the combination of the artisan nature of the improvements and the lack of confidence the entrepreneurs have in such a protection system.

The observations above may explain the reluctance shown by many entrepreneurs interviewed to offer information on the technological developments "in folder." If the degree of appropriability of the technological advancements is too low, the entrepreneurs are likely to rely on the surprise factor to increase the period of primacy in the market of their new products or modifications. The reluctance appeared especially in entrepreneurs who were studying diverse automation mechanisms of their machines, as well as the incorporation of electronic elements of measurement and control.

Quality Control

One of the most remarkable shortcomings concerning the technological structure of the sector is the equipment for quality control existing in the firms. Only three of the 23 firms visited have equipment above the acceptable level. In one case, the firm that is perhaps the leader of the sector has a top-level facility installed, with sophisticated equipment, specialized personnel, and a control routine that covers virtually 100% of the pieces incorporated in the machines. In the second firm, a department is being organized, with somewhat obsolete equipment but with fairly strict control of the pieces in process and the final product. The third firm is a small one, producing special machines, which has recently purchased a very high-precision electronic machine, the only one in the country, which guarantees a rigorous control of all the components.

The remaining firms surveyed show all kinds of deficiencies in this field, both in their equipment and in the verification procedures used, which results in the lack of integration of quality control in the whole process of machine production. The lack is not compensated for by state institutions - such as INTI - as may be inferred from the entrepreneurs' responses; in the majority of cases, they had negative experiences whenever they resorted to it.

Parts and Accessories Producers

The machine tools sector, given its size and other characteristics referred to throughout this section, is not in itself an inductor of technical change in parts and accessories, but rather a passive beneficiary of the advancements generated for use in other sectors. This observation might account for the characteristics of the technological evolution at the second stage, in which one of the dominant elements is the incorporation of parts and accessories into the basic structure of the machine tools.

During the visit to parts and accessories factories, an "integration surplus" could be observed, determined by the existence of highly sophisticated production and control machines with a low degree of utilization. This can be explained by the following: (a) there is a need to have those machines available to maintain the rhythm imposed by the competition and the requirements of the terminal industries; and (b) there is an absolute lack of external technological support - particularly in measurement instruments - to which the producers could resort instead of making the large investments involved in their individual acquisition.

To summarize, the role of the industry producing parts and accessories for machine tools appears to be the major determinant of the technological evolution characteristics of the latter, which became a passive beneficiary of the developments demanded by other sectors. If the machine tools sector starts producing highly sophisticated machines with total automation, the requirements imposed by this new stage - as can already be observed in the case of some special machines - will cause the machine tools manufacturers to become active agents for the technological development of parts and accessories.

Sales

The first relevant element concerning the sales function is to determine the percentage of total sales that is channeled through distributors. The data obtained by the FM study yield the following results, in percentages of total sales of the sector, for 1971:

- direct sales by the manufacturers: 44.7%
- sales through distributors: 55.3%

To measure the organization of the sales structure and its differentiation, it is assumed that this function is differentiated whenever a professionalized structure exists whose exclusive function is to devote itself to handling the firm's sales. This leads one to include within such a category not only those firms with a sales managership, but also the ones that sell their products through distributors, who thus cover the sales function externally (2). The results were the following:

Differentiated:	12 (50%), seven of which sell through distributors; hence only five have a sales managership.
Undifferentiated:	11 (50%), firms in which the sales function is handled by one person who also performs other functions (purchases, financial, etc.)

Out of the seven firms selling through distributors, only four do it through exclusive distributors. The importance of this point lies in the fact that the distributors absorb the drops in cyclic demand (by accumulating stocks), but only with the firms for which they are exclusive distributors. Thus, there are three firms that in the event of important drops in the demand may become disarmed and are without a sales structure of their own.

Conclusions

From the evidence gathered, the general conclusion is that the sector as a whole has little possibility of accompanying a process of sustained growth of the technological requirements imposed by the demand, and of enlarging its participation in the external market, unless some characteristics of the environment, of the firms themselves, and of the products manufactured are modified.

The firms of the sector are passive recipients of the technological requirements imposed by the demand, which for the levels of greater sophistication correspond to the large foreign firms, particularly those of the automotive sector. Hence, a policy for the machine tools sector cannot neglect the action on the demanding agents.

This action on the demanding firms should be one of the forms in which the modification in the action patterns of the state is expressed, which must begin with its top priority participation in the global accumulation and a reform in its capacity for planning and expressing its technological demands, channeling the same primarily toward the national capital.

In the same sense, the effectiveness of policy proposals depends on the role that the global policy would assign to the small and medium national firms.

The overall technological policy must aim to modify the characteristics of locally manufactured products. With respect to this, the proposals must make a distinction between the type of locally manufactured products and their constructive characteristics.

With the exception of the large-size or totally automatic machines, the Argentinian production covers a very broad spectrum of needs, particularly in the simpler levels. The advanced constructive characteristics, on the other hand, are concentrated in a very small number of firms that manufacture special or semiautomatic machines, particularly by cuttings.

The simpler machines are especially suited to the current needs of the Latin American and African market, as is demonstrated by the average value of the machines exported to those markets. Likewise, the demand for these machines will increase to the extent that new developments take place in the sector producing capital and durable consumer goods in those countries. The experience accumulated and the capacity setup in Argentina, in relation to potential competitors in the area, assure the country excellent possibilities to become one of the main suppliers of this type of machine, provided that: (a) a gradual process of incorporation of constructive improvements takes place, particularly those referred to as kinematic features and systems of measurement and control, in accordance with international norms; (b) competitive and stable prices are obtained in the long term; and (c) systems of "service" are established, similar to those offered by the more sought-after foreign suppliers, for which Argentina has the advantage of physical proximity within Latin America.

These proposals, to attain a greater penetration of the simpler and lighter-weight machines in the Latin American and African markets, will not be achieved if the trend that the sector has shown up to the present is continued. An external "push," of the type proposed next, is needed.

The machines having greater weight and value - those $3,500 per ton - are the ones that have shown the greatest incorporation of technological advancements, although they are concentrated in a small number of firms. For lathes, milling machines, and some transfer and special machines, the field is favourable for getting into numerical control, as the next step in the technological evolution of the firms. The advisability of taking this step lies not only in the need to gain ground in a market supplied by imports, but, above all, in the experience derived from the set of problems that must be resolved to reach the peak in the application of numerical control to a machine tool. This is a typical case in which the "dragging effect" may modify the technological characteristics of the whole industry.

From the study of the possibilities afforded by the technological evolution at the world level, described below, it becomes evident that the "secret" is the opening up of the technological package constituted by the design, the constructive characteristics, and the parts and accessories, in such a way that a process of gradual substitution of national elements for foreign ones could be carried out, at the same time strengthening the local learning. Argentina, because of its tradition in the industry and the capacity inherent in its scientific system, has an initial advantage with respect to the other countries of the area in attempting developments in this field.

The total current demand for national machines tools - just above $25 million - has a dimension that, at least in international comparisons, turns out to be insufficient for aiming at significant projects of technological development. This low global demand is much lower still at the level of specific products, in a structure excessively atomized, especially for the products of more complex technology.

Both situations, instability and size of the market, explain the limited growth of the productive capacity observable in the sector. Not only has the supply grown much less than the demand in recent years, but during periods of great increases in demand, such as the one corresponding to the time of the survey, most firms work only one shift, even though their orders may exceed 6 months of production.

In this context, expansion via the external market turns out to be the main means to guarantee a secure and long-term increase in the national productive capacity. Argentina has lost relative participation in the expansion of imports of machine tools in the Latin American market, particularly if Mexico and Brazil are considered, despite the increase in the total exports of the country. It can be foreseen that, unless the elements determining the exporting activity are modified, Argentina will lose similar opportunities in other countries whose demand for machine tools is beginning to expand considerably, such as Venezuela and Ecuador.

The Argentinian possibilities of exporting to Latin America are at the level of products having an average value around $2,000 and $3,500 per ton, which is the average size of the Argentinian production. This average value is reduced by between 30% and 50% if the markets in question have a low level of development in their technological requirements.

BRAZIL

(The Machine Tools Industry)

The following points are suggested in this section: (a) The model of technology transfer prevalent in the machine tools industry until recently (based on domestically developed technology) was not significantly affected by governmental technology policies, but was brought about by peculiarities in the demand structure of the industry, coupled with factors associated with the general pattern of Brazilian industrialization. (b) The recent upsurge of growth in the machine tools industry, starting around 1970, seems to have been marked by the predominance of a new model of technology transfer, based mainly on the establishment of Brazilian branches of foreign firms. This new development also cannot be understood adequately without reference to the overall nature of recent Brazilian economic growth and the general orientation of governmental economic policy; however, it does not seem to have resulted from any specific set of deliberate technology policies. (c) The trend now seems to be in the direction of a decisive predominance of the new model.

Some Aspects of the Machine Tools Market in Developing Countries

a) Demand: A machine tool can be defined as "a non-portable machine, operated by an external source of power, designed to work as a tool or to form the metal by cutting it, by impact, by pressure of electrical processes, or by a combination of such processes" (3). Its importance as a capital good is clear from the fact that a very large proportion of transformation processes in manufacturing activities generally involves some kind of metal processing. About one-third of all investment in the metalworking industries (nonelectrical machinery, transport equipment, electrical equipment, and metallurgy) corresponds to the purchase of machine tools.

Machine tools can be divided into two broad classes: the standard or multipurpose types, and the special-purpose machines. The former are, as a rule, simpler in conception and can be applied to a wide scope of metalworking operations; an example is the standard lathe. Special-purpose machine tools are devised to perform more complex transformation processes, such as those involving the application of several cutting or deforming operations to the same metal part, and are particularly adequate for the large-scale production of a single type of output.

It is to be expected that the demand for standard-type machine tools should be relatively more important in the first stages of the industrialization process, whereas the development of a more complex industrial structure would favour the increased demand for special-purpose machines. For one thing, the relative importance of small, handicraft-type producers is clearly greater in less-developed industrial economies. In addition, there are reasons to suppose that repair work is more common in those economies than in highly industrialized ones. This latter point deserves some elaboration.

The kind of repair and maintenance (R&M) work that utilizes machine tools has to do mainly with capital goods. It is reasonable to assume that the demand for R&M will be directly related to the average age of the stock of those goods. As their productive equipment grows old, entrepreneurs are faced with the alternative of keeping it in operation - incurring the costs of larger R&M expenditures - or of replacing it with new equipment - incurring the costs of this additional investment. If that new equipment embodies some kind of technological innovation that cannot be incorporated in the existing machinery, its adoption becomes more attractive.

If the owners of equipment are interested in minimizing costs, they will opt for the least-cost alternative. Replacement is bound to be favoured, under those circumstances, if investment plus labour costs associated with the adoption of the new equipment are smaller than the operating costs - including repair and maintenance - associated with the existing equipment. The following points are suggested in this regard:

(1) To the extent that the same models of productive equipment are used in developed and developing economies, it is to be expected that in the latter case, labour being relatively cheaper, replacement will take place later, and the demand for R&M will be larger relative to the capital stock.

(2) In developing economies, where frequently the supply of capital goods is largely dependent on imports, balance-of-payments difficulties may be expected to increase the average life of capital equipment, by increasing the costs of new investment (the increase in the cost of R&M investment, if it takes place in the same proportion, will not be enough to offset this effect).

(3) One should, thus, expect a higher relative demand for the services of multi-purpose machine tools: (a) in developing economies than in highly industrialized ones; and (b) in "bad" than in "good" times (as far as capacity to import is concerned) in developing economies.

b) Technology Transfer: It is generally true that the simpler types of machine tools, which are relatively more demanded in the earlier stages of industrialization, are also simpler to build than the special machines used, for instance, in large-scale production. It is to be expected, then, that the first types of machine tools produced in an industrializing economy are multipurpose machines. The access to technical know-how to produce those simpler machines can also be gained in a comparatively simple manner: the Brazilian experience suggests that the copying of imported machines, often performed by immigrants with limited technical training, will do.

However, the progressive sophistication of the structure of demand for machine tools that follows the industrialization process seems to make import substitution in the machine tools industry progressively more difficult. For one thing, the increase in demand for special-purpose machines means less standardization, smaller production series, and often higher demand for skilled labour, in the production of machine tools. Also, machine tools devised for use in large-scale production are often automated to various degrees, which adds to the complexity of their design and production. It is also true that the technical specifications of machine tool users tend to become more demanding when the industrial structure becomes more complex: a machine tool used in an automobile assembly line has to be more precise than one used to produce the frame for a handcart, for instance.

Machine copying is not enough, now, as a form of acquisition of know-how for the domestic production of machine tools: a new model of technology transfer has to be found.

Evolution of the Brazilian Machine Tools Industry

Operating repair shops and producing in the metalworking branch were the two main previous activities of the first machine tool producers, according to the indications available. Repair shops were a by-product of the first manifestations of industrialization in Brazil. The factories themselves frequently had large maintenance and repair departments, which were often required to make or adapt replacement parts, because of import difficulties or insufficient stocks. It is known that many of these shops evolved, in the 1930s, to equipment producers. One of the firms included in the sample, for instance, was founded in 1931 as a maintenance and repair shop, later entered the machine import business, and finally started to produce its own models.

In many instances, machine tool making started to fulfill a need of the producing firm itself or of one of its clients. One of the firms in the sample, for instance, was established in 1937 by an Italian immigrant to produce movie projectors. As the firm needed a milling machine larger than the models available in the market, it decided to produce one. Other firms soon asked the firm to produce additional units and it was forced to open this line of production. After some years it specialized completely in milling machines.

Very similar is the story of the largest lathe producer in Brazil, now a big concern with an extensive export business. The founder, also an Italian immigrant, started in 1938 as a plowmaker and only produced the first lathe because he needed one.

The role of immigrants, as illustrated in the above examples, was no doubt predominant in the beginnings of the machine tools industry (4). Being familiar with the utilization or the construction of those machines, Italian, German, and Spanish immigrants, among others, were an important source of technical knowledge in the period. Even today, firms established by immigrants are numerically important: the majority of Brazilian firms in our sample, for instance, had been founded by first-generation immigrants.

Prohibitions on imports of equipment during 1931-1937 caused an increased demand for repair and maintenance services, with positive effects on the demand for machine tools.

Copying foreign models was - and, to a large extent, still is - the standard means of designing a new model for domestic production. The imported machines are disassembled, and an effort is made to reproduce their parts, if possible using the same material; when necessary, simplifications or adaptations are performed. It is probable that in the initial stages of development of the industry, the copying process was sometimes crude and the final product lacking in precision. However, the type of demand to be satisfied was such as to make mechanical exactness unnecessary, especially since there were obstacles to importation. Copying was, therefore, an effective way to absorb know-how from abroad.

World War II marked an extension of the period of import difficulties. There are indications, however, that the lack of imported materials, especially steel, had an offsetting influence on the development of the domestic production of equipment (5).

After World War II, exchange regulations appear as the main policy instrument affecting the industrialization process (6). While the effect of the adopted policies favoured the internal production of consumer goods, domestic equipment production was hampered by the preferential treatment given to imports in this category.

Immediately after the War, there were no obstacles to imports even though the fixed exchange rate was rather overvalued. With the rapid exhaustion of the country's international reserves, the government opted for a direct control of imports rather than a devaluation, partly with the purpose of avoiding inflationary pressures. Foreign exchange was alloted to importers according to criteria based on how essential the goods to be imported were. By and large, machinery and some inputs were attributed high priority, while luxuries and goods that could be produced internally were penalized. The system was, thus, especially favourable to the internal production of difficult-to-import goods: protection from external competition was assured, and at the same time it was possible to import the necessary machinery at an overvalued exchange rate. By the same token, however, domestic production of machinery was discouraged. This effect was felt in the machine tools sector, and some firms were forced to abandon this line of production. By 1949, 68.9% of the value of the internal supply of metalworking machinery corresponded to imports (7).

The rapid growth of industrial output in the early 1950s would, on the other hand, create a derived demand for machine tools, resulting in a renewed interest for local production.

In 1955, the total Brazilian output of machine tools was about 4,500 units, and imports corresponded to only 34.7%, in number of units, of the internal supply (and 53.9%, in weight).

Exchange policy tended to direct investment to the more protected sectors; and the models of higher technological content, in which foreign producers would have a clear advantage, were being imported without restrictions.

To sum up, the early development of the machine tools industry was marked by the predominance of nationally owned firms. This characteristic, even though affected by various governmental actions, was not the result of deliberate policies.

Implemented Policies of the Machine Tools Industry

The government made no major attempt to implement the objective of internal development, as far as the domestic capital goods industry was concerned. On the other hand, exemptions for the importation of industrial equipment were generalized. Following the GEIA scheme, Executive Groups for various industries were created in the 1960s and were consolidated in 1969 under the Council for Industrial Development. The Council, which had the task of examining requests for equipment importation with the purpose of granting the exemption of tariffs and other taxes, in fact approved the requests wholesale. This illustrates the fact that growth of product had absolute priority over technological autonomy.

The policy of easy imports was made possible not only by the rapid expansion in exports from 1968 on (an average yearly growth of about 30%), but also by the large inflow of loan capital from abroad, especially in the 1970s. Contrary to the 1955-1961 period, when high growth rates went together with a tight balance-of-payments situation, Brazil now had rapid growth and high capacity to import. Paradoxically, the former situation may more easily lead to favourable policies toward the domestic capital goods industry than the latter one.

Another decision related to imports that seems to have had an important effect on the machine tools industry was the possibility of tariffs. Producers could, by act of the Council for Industrial Development, be allowed to include imported components in their output, having the same benefits granted to the importation of productive equipment. This measure was enacted in 1970 and regulated in 1971-1972.

In the second half of 1975, the worsening of the balance-of-payments situation forced the government to impose drastic restrictions on imports and, on the other hand, to embark on a vigorous program of incentives to the domestic capital goods industry. It is, of course, too early to assess the impact of these measures upon the machine tools industry.

Entry of Foreign Firms

Most Brazilian businesspeople were apprehensive about the increase in the number of foreign firms in the sector. Even though the new producers presently do not have, in general, a line of production competitive with national firms, it is thought that, in the event of a reduction in the demand for their traditional products, they will shift to simpler, multipurpose machines, whose demand tends to fluctuate less. In this case the foreign firms might easily, it is thought, throw the Brazilian producers out of the market.

The prediction of a shift in production by the foreign firms is certainly correct: it is technically possible, and it is the logical way out in case of market difficulties. One of the foreign firm managers interviewed actually confirmed his intention of acting in this way.

With regard to the reasons for the present inflow of foreign capital into the sector, it is thought that, besides factors such as good market propsects and cheap labour, some policy measures were also instrumental in attracting the foreign firms. The possibility of importing complementary parts with duty exemptions was apparently important in this respect, as were the export incentives.

Big purchasers of machine tools that are branches of foreign firms seem to play a significant role in prompting their suppliers abroad to open a Brazilian affiliate. Thus, the manager of a German subsidiary mentioned that his firm had come to Brazil through the recommendation of Volkswagen, for which they were projecting a new assembly line. Also, the establishment of the Fiat plant is now bringing in its wake some Italian machine tool makers.

As far as Italian firms are concerned, an "expulsion" factor is generally mentioned: the fear of the rise to power of the Communist Party in Italy. If present electoral trends continue in that country, a rush of Italian firms to open Brazilian subsidiaries is predicted.

Another factor working in the same direction in Germany seems to be the increase in the value of the mark vis-à-vis the dollar. The consequent loss of the competitive position of German exports induces producers in that country to open branches in the dollar areas.

Domestic Technological Development

When asked about their possibilities of developing the new models required by the market, the Brazilian producers generally insisted that they would be able, with enough time and resources at their disposal, to design and construct the machines. Copying would still be, even for the development of more sophisticated machines, an effective method of technology transfer. Licencing would not, in the view of some businesspeople, be a very appropriate means, because the foreign producers are in general reluctant to see blueprints for their newest models. On the other hand, it would be easy to circumvent problems, when they exist, by means of a "mixing" of various imported machines. The bottlenecks would then be: the necessity to start producing new models quickly, because of the competition ("the market cannot wait," said one of the interviewees); the scarcity of sources of capital to finance the development and testing of prototypes; and the scarcity of technically trained labour.

In the same vein, some Brazilian businesspeople who had sold or were contemplating selling part of their business to a foreign firm (which in general insists on assuming control) maintained that, as one of them put it, their problem "was not technology, but capital."

In accordance with their answers about technology transfer, when asked about what the government could do to foster the domestic development of technical processes the interviewees mentioned: (a) various financing schemes for the development of new models: nonreturnable grants, loans at interest rates, purchase of prototypes by the government, deduction from taxable revenue of a part of the expenses on research and development, etc.; (b) financing for the training of skilled workers and technical staff, especially abroad; (c) importation of selected modern machines for copying; (d) improvement of technical education in general; and (e) creation or improvement of technological research institutions.

Incentives to the Importation of Equipment

The granting of benefits for the importation of equipment has been one of the main policy instruments to foster investment in certain industrial sectors. As was seen above, in general those benefits are only granted if the machine to be imported is not produced locally. The existence of a national "similar" (which, according to the present procedures, is judged by the industry associations themselves) should in principle preclude tariff-exempt imports. Good application of the "law of similars" is, thus, of crucial importance for domestic machine makers.

When asked about how well the machine tools industry was protected by this mechanism, the majority of the respondents were pessimistic. In fact, 12 out of 20 answers expressed misgivings about it. The main problem seems to be the possibility of proving similarity in practice. According to the law, to be considered similar to the imported product the domestic equipment has to have: the same quality and technical specifications; a price not higher than that of the imported product, including tariffs and taxes; and normal time of delivery. Apparently, there are many ways to circumvent those rules. Importers may, for instance, place their orders abroad and only request the import licence some months later, so that no domestic producer can match the delivery time. Or they can make some exaggerated technical specifications, which they know can be satisfied by the foreign producer, but not by the domestic one, at a small additional cost.

On the other hand, complaints are also made in relation to the fact that tariffs are too low, so that foreign machines similar to domestically produced ones are imported in large scale, all duties being paid. The solution, according to the respondents, would be the downright prohibition of the importation of goods with a domestically produced similar.

The worsening of the balance-of-payments situation, from 1974 on, has caused the government to adopt a less permissive attitude toward equipment imports, by simply delaying the exemption requests. Many answers indirectly expressed this fact when they mentioned the "more correct" position of the authorities in the last months.

Concluding Remarks

As the preceding pages attempted to show, the Brazilian machine tools industry is presently going through a transition stage. The entry of foreign subsidiaries, initiated in the last few years, will probably alter substantially the property structure of the industry. This fact marks, on the other hand, the adoption of a new model of technological development. Whereas up to now the prevalent mode of absorption and development of technology was internal to the domestic plant (via copying of models, autonomous research and development, or a mixture of both), under the new model research and development will be typically restricted to the home company, and the absorption of new methods will be made by the simple importation of blueprints. It is highly probable that the recent measures adopted by the government, with a view to further internal production of capital goods, will have the effect of accelerating those transformations.

Judging by the formulations of the last governmental plans, the new technological development model would be contrary to the objectives and policies of the government in the technology field, resulting in conflicting goals. Taking a broader view, however, it can be seen that the basic objective of government in the last decade has been the achievement and maintenance of high rates of GNP growth; in a sense, all other goals are subordinated. To the extent that the machine tools sector did not create bottlenecks to growth, its performance supported the main objective of governmental policy.

The adoption of a different model of technological development in the industry would require a very diverse context. As was said above, the direction taken by the growth of the economy during the post-1967 boom was probably the most important factor to precipitate the changes in the sector. It is not clear, however, whether a period of sustained growth based not on consumer durables, but on the development of a mass market for wage goods, could lead automatically to a very different model of technology development. As was seen earlier, the more technologically advanced machine tools are characteristically demanded in highly industrialized economies; the product-mix is not the crucial factor in the long run.

In case the presently evolving model is considered unacceptable, positive governmental action - probably of the kind envisaged by the producers themselves - seems to be the only alternative.

KOREA

(The Powder Metallurgy Industry)

Introduction

The powder metallurgy industry is a typical example of a small- or medium-size technology-intensive industry at its growth stage in Korea.

Present Status

Powder metallurgy is a technique of producing metal and ceramic products from fine powders. The basic process is quite similar to the production of bricks, but in recent years many parts for machines and electrical devices have been produced by this process. The first step in the powder metallurgy process is the production of powders from ores or bulk metals. The powders are then mixed to specific compositions, compacted in a die to a desired shape, and sintered in a high-temperatures furnace to obtain mechanical strength and other desired properties. After sintering, the products are subjected to additional treatments such as surface carburization or sizing.

In industrial practice, the powder production is considered to be a part of raw materials processing and is usually separated from the production of parts with powder. For an analysis of powder metallurgy technology, it is therefore convenient to consider the metal and ceramic powders as the major raw material input to the industry. The major pieces of capital equipment are compacting presses, sintering furnaces, mixers, and die-making machine shop, if the dies are made within a firm. A powder metallurgy operation may also have some surface-treating furnaces and a simple testing laboratory.

Since small parts of complex shapes can be mass produced to great accuracy, the major powder metallurgy products are the structure parts for machines and electrical devices. It is estimated, for example, that about one hundred parts in an automobile are made by this process. The next major products are the refractory metal parts, which are difficult to fabricate by other methods because of high melting temperatures.

Since the powder metallurgy industry produces parts for the machinery and electrical industry, its customers are usually firms engaged in assembling products for consumers. The purchasing departments of these firms are sometimes represented or supported by competent technical personnel, and thus the powder metallurgy firms are required to pay much attention to technical problems in their sales activities. The powder metallurgy parts are typically produced on custom order and, therefore, a firm needs the capability to design and alter products and processes to stringent specifications. Usually the products of a firm vary greatly in composition, shape, and properties. Powder metallurgy is therefore a fairly technology-intensive industry.

In addition, a firm can produce a large variety of products with essentially the same production facility. Therefore, a simple turn-key type of technology import for a specific product is extremely costly. A powder metallurgy firm thus has to absorb the basic technology fully and obtain the capability for developing new products and even providing engineering services to customers.

The powder metallurgy industry in Korea began around 1970 to meet the growing demands for the machine and electronic parts that had been imported. Presently, the major powder metallurgy products are the metal structural parts for machines, tungsten carbide cutting tools, and ferrites and ceramic capacitors for electronic parts. This study concentrated on the metal structural parts powder metallurgy firms.

There are presently four major metal structural parts powder metallurgy firms in Korea. The first one began production at a small scale around 1968 and one firm is going through the initial operation stage. All of them produce about the same size, with an average capital investment of about half a million dollars. The average number of employees is about 40, with two or three college graduate engineers. Three firms are owned exclusively by the company head and produce only powder metallurgy products. One factory is a part of one of the largest machinery firms. Their present and potential market shares are about the same. These firms meet only part of the demands for powder metallurgy products in Korea and a large portion still has to be imported.

With a rapidly growing machinery and electrical industry in Korea, the demand for these products is increasing. The firms are striving to initiate production of the parts that are presently being imported. Some firms also have plans to expand to entirely different types of products such as tungsten base cutting tools and magnetic ceramics.

The major sources of capital are loans from banks in Korea and international agencies such as the Asian Development Bank. So far there has been no joint venture with a foreign firm or direct investment by a foreign company.

The technology for this industry has been acquired through published literature, foreign company specifications, foreign standards, and technical information provided by the foreign suppliers of the capital equipment and raw materials. In addition, there has apparently been some exchange of information among the technical personnel at various firms. There has been no organized import of technology through means such as licencing, the use of patents, or technical aid agreements. Therefore, the effectiveness of technology acquisition at various firms depended heavily on the ability and motivation of the engineers.

The large, established electrical appliance firms, which are the customers of these products, assisted and stimulated the development of powder metallurgy products. Initially, the parts were imported from Japan, but because of high price and difficulty of supply the electrical appliance firms encouraged the establishment of powder metallurgy firms. They even provided technical and material specifications. Subsequently, with a fairly competent group of technical staff and testing capability, they stimulated quality improvement by raising the standard of the quality demanded of the products. At this stage of development, however, the technical assistance that can be provided by the large customer companies is reaching a limit and the powder metallurgy companies themselves are expected to assume a leading role in further technical advancement.

The research and development work in powder metallurgy in Korea has been minimal. Some academic research was performed at a university and at the Korea Institute of Science and Technology (KIST), but their experience was not sufficient to provide the technical know-how required for the actual production of the commercial parts. Recently, the Korea Advanced Institute of Science (KAIS) started a strong research and education program to provide and accumulate know-how and basic understanding of the powder metallurgy technology required by the industry.

Although there are a few government and public organizations that could have played an important linkage role between the industry and technology sources, none apparently played any significant part. The trading companies that handle the purchase of capital equipment and raw materials sometimes conveyed technical information from the foreign sources.

In summary, the powder metallurgy industry in Korea is a typical example of a small- or medium-size technology-intensive industry in the growth stage without much organized technical input from foreign sources. This is an area where technical ingenuity and innovation can be an important factor in the success or failure of a firm.

Import Substitution Policy

The import substitution policy aims at improving the international balance of payments and protecting the infant domestic industry through restrictions of imports. For most of the industrial products, the permission for importation is granted after examining the capability of domestic production, price comparisons between the domestic and foreign products, contributions to export, and so forth. In addition, tariffs ranging from about 10% to 100% are imposed, with rates determined by a certain set of criteria including the capability of domestic production. This policy affects the powder metallurgy industry in both the purchase of capital equipment and raw materials and the marketing of its products.

The import substitution policy thus aims at reducing the importation of the foreign capital equipment and raw materials by the powder metallurgy industry and also the foreign powder metallurgy products by the domestic users. This policy therefore protects the powder metallurgy industry from international competition while forcing the firms to utilize inputs from the domestic sources.

Although granting the import licence is supposed to be based on the possibility of domestic production at the required quality standard and a comparable price, it was found that the judgment and final decision for a large group of products such as the electrical products were made by one or two individuals based mainly on their personal knowledge and experience. With the wide variety and complexity of the products and rapid changes in the industrial capability, it appeared that it would be almost impossible for a few individuals to make a sound and consistent decision. In the same way it is suspected that determining differentiated tariff rates based in part on domestic production capability would be an extremely difficult task.

A few examples illustrating these points can be cited. For the sintering furnace, which is one of the major pieces of capital equipment, it was found that the tariff for the complete unit was 5% while for the furnace parts the rates were about 30%, thereby placing the domestic furnace producers at a disadvantage. For the mechanical presses, the firms experienced difficulties and delays in obtaining an import licence because all mechanical presses in principle were not allowed to be imported. This was because the usual types could be produced domestically and the authorities could not be easily persuaded that powder metallurgy required precision presses. Another example is iron powder, which is the most important raw material. Although iron powder is not produced at all in Korea, a 10% tariff is levied and in this case the import substitution could certainly not be the justification for the tariff.

Copper powder, which is another important raw material, presents an interesting case. With the introduction of the powder metallurgy industry, copper powder production was started in Korea. Because supply from Japan was more expensive as a result of the tariff and export expenses, the firms have been using the domestic copper powder over the years. But ironically, as the technology was improved and the customer firms began demanding higher quality, it was found that the standard required could not be easily satisfied with domestic powders. As the firms began searching for sources of better quality powder, it was found that a large well-known American firm could supply the powder at a price comparable to the domestic sources, even with the tariff. Thus some firms began using the American powder and could satisfy the standards required by the customers. This example illustrates the complexities involved in the evolution of the import substitution process and shows that advancement of technology can cause even a reversal of the process.

It appeared and was admitted by persons engaged in granting the import permits that the implementation of this policy provided essentially a red tape for import that is cumbersome enough to encourage the utilization of domestic products. In addition, it appeared that the import substitution policy was not clearly distinguished from general import restraining goals or even from increasing the government revenue. Thus the importers almost tended to regard the tariff system as some penalty to be paid for any kind of import from abroad. From these observations it was concluded that the import substitution policy, based on import restriction, contains inherent weaknesses for rational implementation.

The powder metallurgy firms generally agreed that the import restriction system was effective in promoting the initiation of this industry in Korea and without this policy the introduction of this industry to Korea probably would have been delayed. Under the protection of import ban or high tariffs, the first powder metallurgy firm established in Korea enjoyed a virtually monopolistic position free from foreign competition, at least for a large portion of the products. Therefore, it can be concluded that in spite of the difficulty of rational application this policy was effective in promoting the introduction of this technology to Korea and creating a demand for such a technology.

After the initial stage, however, there was little incentive for the first firm, which enjoyed a monopolistic position, to improve the quality of its products. It was readily admitted that the quality was below the international standards and there was little incentive for improvement in the absence of competition. As new firms appeared offering competition, these firms showed much interest in improving the quality, and the large customer firms could in effect play them against each other for quality as well as price.

Presently, there are still a number of types of powder metallurgy products that are being imported under low tariff rates because these products cannot be made in Korea. The firms are striving to break into these new products. But often, even when products of high quality are introduced, the customer firms cannot be easily persuaded to utilize them. The first reason is that the customer firms have a natural inertia against turning to new unaccustomed suppliers, especially when it is a domestic firm. Thus the customers tend to use foreign suppliers in spite of high tariffs and red tape in importation.

But during the interviews, it was found that the reasons for the continuous reliance on foreign capital goods and intermediate goods, of which the powder metallurgy products are typical, lie in two factors that are almost contextual in Korea. The first is that in an organization the performance of a person or a group is judged more by mistakes than by positive contributions. Therefore, engineers or the management of a firm are very reluctant to assume responsibility for the risks in using domestic products when only a small credit is expected for the possible benefits from it. Therefore, the engineers actually are more likely to insist on using foreign capital and intermediate goods. The second reason lies in the absence of a close linkage between the management and the technical staff and the small participation of the engineering staff in management within firms. If the management can make sound technical evaluations and assume responsibility for them, the imported products can be more readily replaced by domestic products.

As expected, the lack of technical capability and experience of the powder metallurgy firms, firms supplying capital goods to them, and the customer firms, was a large hindering factor in the effective promotion of import substitution. The capital equipment and powder metallurgy firms do not have the knowledge and facilities for testing and thereby guaranteeing the quality of their products, and the customer firms face the same problem for the products they receive. Furthermore, even with some capability for testing by both the supplier and the customer, it is quite difficult to agree on common methods and criteria. This problem essentially relates to the lack of standardization for products and test procedures. The customer companies were therefore more likely to rely on foreign suppliers of guaranteed quality rather than venturing into new domestic suppliers whose products could not be tested reliably. The domestic producer then effectively could not receive due credit for the products that may indeed have been of high quality.

As described earlier, the import substitution policy was effective in promoting the early introduction of the powder metallurgy industry in Korea. Presently, however, even with several firms in competition, the products are of higher price and lower quality than the foreign products. It was found that the powder metallurgy firms turned largely to foreign capital equipment and raw materials in spite of the tariffs and red tape for import licences. Thus the product prices became higher, but the products could be sold in the domestic market because importation of these products was restricted through high tariffs. In the domestic market, therefore, the price of the final products containing powder metallurgy parts would tend to be higher than the international market price. This kind of closed circle in increasing prices can be fatal in export promotion, since the domestic products cannot compete internationally because of high prices.

There is some evidence that the tariff system may in effect cause high prices for domestic raw materials. The domestic producers can increase the prices up to the point at which they can compete with foreign products on which tariffs are imposed. Therefore, the domestic products are sometimes priced at the foreign product level plus the tariff.

It appears that the most important issue in the import substitution policy is how to promote the changeover from the import substitution stage to the export stage. With a limited domestic market and heavy reliance on exports in Korea this problem is more acute than in other countries. In Korea an industry like powder metallurgy cannot be expected to grow over a long period without export markets.

The import substitution policy can cause other inhibiting factors for export promotion in addition to the high price. The study of these firms indicates that producing for the domestic market protected by tariffs and import restrictions provided little incentive for the improvement of technology and management to a level substantially higher than the current level maintained by other firms. Once the inertia of inefficient operation is built up over the years, the firms will continue to depend on the umbrella of the tariff system even for the domestic market and will be unprepared to move ahead to the export stage.

Support for Research and Development

The major government effort for R&D has been through the establishment and support of R&D institutions and annual grants to research workers. In powder metallurgy one firm that is a part of a large machinery corporation was able to support a research program at KAIS, with half of the funds provided by the government under the Technology Promotion Law. The research at KAIS put emphasis on identifying and solving the actual problems arising in initiating the production at the firm, and in part as a result of the inputs from this program the firm was able to initiate production and rapidly acquire the needed technology. In addition, the research at KAIS was continued with the aim of understanding the basic technology and training graduate students. Thus the immediate requirements of the firm were met through a problem-solving type of approach while developing and accumulating the basic knowledge of the technology. Another firm received some service from KIST, but the activities and financial support were meager.

This successful research effort appears to be an exception rather than typical. The other powder metallurgy firms did not receive any assistance from a government-supported institution or program. And the decision for support of research at KAIS was not based on any systematic analysis of the technology requirements in the industry. It was realized through the initiative of the Ministry of Science and Technology, the firm, and the team at KAIS.

It can be concluded therefore that although a part of the need for technology was supplied through an exemplary R&D program, the overall requirements were not even systematically analyzed for possible support. Thus the import substitution policy created a demand for technology, but it could not be adequately supplied through the R&D program. If a closer linkage between the two policies had been established, it may have been possible to satisfy the demand for technology more widely and efficiently.

Conclusions and Recommendations

An analysis of the import substitution policy and its implementation shows that such a policy relying solely on tariffs and import restrictions can hardly be applied selectively for different types of products and at different degrees of restriction. Lacking selectivity, it is doubtful whether such a policy is any different from the general import restriction motivated more strongly by the desire to save foreign currency than any specific goals for import substitution.

In spite of the difficulty for rational implementation, the import restriction was instrumental in initiating this industry, and presently the domestic requirements for the products are being satisfied at increasing scale. The export of these products is expected to encounter difficulties because of high price, low quality, and inefficient operation of the firms, which were due in part to the protection provided by import restriction. The major problem at this stage is how to promote the changeover from the import substitution stage to export expansion. Presently, the Korean government is going through an intensive review of the import substitution policy.

This study also concluded that while the demand for technology was created by import restriction measures, no systematic means for supplying the technology were provided. To expose the industry to the international competition without restrictions, it is first essential for the firms to enhance their level of technology.

Since the typical powder metallurgy firms are small or medium size, they are not capable of supporting a research and development program on their own or even of paying for an extensive consulting service. Joint support for R&D by a group of similar small and medium industries is often suggested as a remedy, but the impression obtained during this study was that it would be extremely difficult to realize because of the competitive advantage each firm can gain from new developments. It was therefore concluded that in this type of technology-intensive small and medium industry, government and public support for research is necessary.

But the technical requirements of the industry are not expected to be satisfied by the usual R&D programs following the patterns in advanced countries. It is first necessary to determine the nature of technical need in these industries. At this stage of development the powder metallurgy industry in Korea needs the ability to produce the items that are identical or similar to those produced in foreign countries. To do this, it is first necessary for them to obtain and digest the information on product specifications from foreign industrial standards and company specifications. Then they would need the ability to adapt and modify the foreign specifications, to design the product, and to establish processing conditions. Finally - and probably most importantly - they have to know the methods for quality control, which involves decreasing the reject rates and improving the efficiency.

The need for developing an entirely new type of product, which the usual R&D activities are expected to supply, is smaller than for these basic technologies required for the daily operation of the firms. Therefore these needs have to be assessed and incorporated into any technical development program aimed at providing the technical service required by these firms. This observation probably is quite generally applicable to most of the emerging industries in developing countries, and this point probably distinguishes the type of R&D required by the developing countries from that needed by the advanced countries.

The government support for R&D can take various forms, from establishing a laboratory for powder metallurgy as was done in Brazil to awarding concentrated financial grants to a university or research group. But it is essential to incorporate the technical service to the industries as a major element of the program. Therefore, the program may contain not only the research and development for a new product or process, but also dissemination of the results to the industry, education of the technical staff in the industry, and the provision of related technical services for obtaining information, designing new products, and improving quality control. Such a program can contain, for example, financial support for holding seminars and workshops for providing these services.

For these activities it probably will be essential for the firms themselves to share a part of the financial burden. In addition to the obvious need for financial support for such activities, the firms are likely to absorb what is offered more efficiently if they actively participate in them to the extent of sharing the financial burden. In addition, the degree of participation by the firms can then provide a yardstick for measuring the need for and effectiveness of such a program.

In summary, examination of the powder metallurgy industry revealed that while the demand for technology was created by the import substitution policy based on import restriction, the technology required could not be effectively supplied by the R&D program supported by the explicit policy. It thus became apparent that the import substitution policy, to be effective, should incorporate and be coordinated with the programs for supporting R&D.

But the need for a close linkage with the R&D program illustrates only a part of the present problem. This study revealed that the policy instruments on the transfer of foreign technology, standardization, export promotion, engineering consultancy, and financing did not produce any marked effect on the development of the powder metallurgy industry in Korea. Since the import substitution is in essence the first stage of industrial and technological development, it should be closely coordinated with these other policies as well. A firmer ground for international competition can be established if the import substitution policy extends beyond import restrictions to other measures for supporting the increased efficiency of the firms.

INDIA

(The Electronics Industry)

Current Status of the Industry

The electronics industry in India today is poised for rapid growth. It is increasingly playing an important role in the national development. Starting with the manufacture of radio receivers by a few private firms in the early 1950s, the industry has not only grown in total volume but also has diversified enormously over the last 25 years. In fact, there is hardly any major sector of the economy in which electronics does not find some use. The recent trends have been toward the growth of professional electronics and self-reliance in many of the high-technology areas, the pace for which has been set by the rapid growth of the consumer electronics sector since the submission of the Bhabha Committee report.

A survey of the national developments in the country indicates the vital role played by the electronics industry. More than 85% of India's population is now covered by the mass communication media like radio and television. The defence system is now being based more and more on the indigenously manufactured equipment and systems. The process control instrumentation is being increasingly used for optimizing the outputs of various process and manufacturing industries like fertilizers, petrochemicals, etc. Indigenously produced computers are being used in some cases. In the bid to become self-sufficient in power requirements, India has embarked on major developments in the areas of nuclear and other power sources. Electronics play a pivotal role in the control of nuclear reactors and the optimal distribution of power through the grids. The launching of the first Indian satellite is testimony of the excellence in the ability to design and implement complex projects involving a myriad of electronic systems. The SITE program has played a significant role in the education of the rural population.

The era of rapid development of the electronics industry may be traced to the establishment of the electronics committee by the Government of India.

The report of the Bhabha Committee, which was submitted in 1966, brought forth the need for intensified growth of this industry along predominantly indigenous lines. The report, which, for the first time, quantified the status of the electronics industry and the needs for the 1969-1975 period, presented a master plan for the development of this key sector.

Since the time of the Bhabha Committee the consumer electronics sector has grown at more than twice the rate suggested by the report. However, the growth rate of the professional electronics area was much slower than the suggested one.

During the past decade the industry has been growing steadily, and over the past 5 years the industry has grown at an average annual rate of over 20%. During this period the consumer electronics sector experienced a geometric growth rate, whereas the professional electronics industry followed the linear growth pattern. The last decade also saw the emergence of the small-scale sector in a big way and many of the firms in this sector have been started by technical entrepreneurs. The commercial viability of the small-scale units has been amply demonstrated by the high-quality consumer electronic items, test and measuring instruments, medical electronic equipment, etc., in this sector. A main thrust behind the country's self-reliance and self-sufficiency in the consumer items has been from the well-established base in the organized private sector and the small-scale manufacturers. The private sector is also responsible for the substantial export of electronic items. This sector, besides pioneering in desk calculators, has also entered into areas like radio frequency cables, microwave components, digital instruments, control equipment, etc.

Role of State Enterprises

Electronics is one industry in which the Indian public sector has continued to play a vital role. There are public sector units that produce sophisticated defence equipment like communication and radar systems, and those that also produce consumer electronic equipment like television. There has been keen competition between different units and also with the private sector units. In some public sector units a large part of the manufacturing know-how has been obtained from foreign sources to minimize the time frame for the production of strategically important items. In a few others the production is totally based on indigenous know-how. In any case, all the units have now established the research and development departments for product diversification and import substitution activities.

Research and Development in Electronics

Electronics is one of the most R&D intensive areas and the advancement of this technology critically depends on the availability of a well-organized R&D base in the country. The Bhabha Committee in 1966 estimated that the R&D outlay for electronics was in the order of Rs4 crores and predicted that by 1975 the annual outlay should be in the order of Rs85 crores. Although the R&D outlay has been less than the expectations, considerable progress has been made in this direction.

In this field of consumer electronics the R&D efforts have been relatively little. It has been estimated that hardly 0.3% of the total sales has been spent on R&D efforts. Piloni has developed technical know-how in TV test instruments, antennas, TV camera monitors, microphones, and other items. Many of these have been successfully transferred to the manufacturing base. The electronic systems division of ISRO has developed a solid-state TV.

In the field of mass communication, most of the R&D work is going on in BEL (state-owned) and AIR; BEL has developed several types of transmitting tubes, high-power valves for broadcasting, and communication equipment. ITI (state-owned) has been engaged in the development of microwave link equipment. Indigenous efforts have resulted in the development of MW transmitters up to 100 kw, TV transmitters and accessories. The development efforts are under way for items like control consoles, studio equipment, TV relay receivers, etc.

The development work in the field of computers is under way at TIFR, BARC, ECIL (state-owned), Jadavpur University, etc. Development work is also being undertaken for different types of peripherals. Considerable efforts in software development are being made by firms in the public and private sectors.

In the field of instruments, considerable progress has been made. Extensive efforts have resulted in the development of a large number of items from digital multimeters to complex medical instruments. The existing R&D activities are in several laboratories under CSIR, the Department of Atomic Energy, ISRO, the Ministry of Defence, and some educational institutions. Some process control instruments are under development at ECIL, IL, Kota, and the Fertilizer Corporation of India. Process control instruments and computer control systems have also been developed.

In the field of communications a major part of R&D activities is carried out by institutions attached to the user departments and in-house R&D units of various organizations. The Telecommunications Research Centre, the Overseas Communications Service Research Centre, laboratories under the Ministry of Defence, and R&D departments of BEL and ITI (both state-owned) and HAL8 account for most of the work done. Significant contributions of TRC are for microwave links, telephone and telegraph equipment, automatic electronic exchange, etc.

ITI has developed a wide variety of telephone equipment, line equipment, intercom systems, equipment for strowger and crossbar exchanges, and narrow-band solid-state systems.

In the case of radar and HF/VHF equipment, BEL, HAL, and LRDE have contributed significantly. A few other laboratories like TIFR, NPL, BARC have been actively engaged in the development of C-band, X-band, and S-band systems, transmitters, transreceivers, LOS systems, and radio relay stations.

The growth of the electronic components and materials industry demands a far greater R&D effort than the sector of equipment. The research groups of BEL, CEERI, NPL, ECIL (state-owned), IISc, etc., have been the leaders in the field. A wide variety of special electron tubes have been developed. National laboratories like SPL, CEERI, and NPL have been engaged in the development of semiconductor devices. NPL has been concentrating on thin film technology. A variety of materials including ferrites and ceramics have been developed. The leaders in the materials development have been CEERI, NPL, NCL, RRL, SPL, CGCRI, and NAL.

The above brief survey indicates that the R&D efforts have been undertaken in the past by different institutions and laboratories. There have been instances of duplication of efforts. To foster the growth of R&D efforts in the country so that it culminates in production, the Electronic Commission established the Technology Development Council (TDC) in 1973. The principal functions of TDC are to assist the Electronics Commission in the identification of areas requiring intensive R&D efforts, assigning the relative priorities and helping the transfer of technology.

TDC is assisted by six working groups of experts in different areas of electronics. The working groups have examined a large number of R&D proposals and have recommended some for high-priority funding and completion. TDC is also expected to examine the questions of the import of know-how and the internal transfer of technology.

Industrial Licencing Policy

According to the licencing policy pursued in electronics, professional telecommunication and electronic equipment has been largely reserved for the public sector, while the rest of the electronics industry has been left open.

An important criterion in the assessment of an application for an industrial licence is the credentials of the party making such an application. The Department of Electronics has laid great emphasis on providing encouragement to technically qualified entrepreneurs, and applications received from such persons are always given higher priority than those made on a pure investment basis. The Department is also in constant touch with Indians abroad who are engaged in the electronics industry and who have expressed a desire to return to their country to participate in meaningful ventures. After their return, the Department helps them to file suitable applications and processes these applications as quickly as possible within the existing framework.

Another important criterion that the Department has been following is to disperse the electronics industry out of the main metropolitan areas of the country. Ever since the industry began in the 1950s, there has been concentration of its growth in three or four centres, notably Delhi (for consumer electronics), Bombay/Poona, Bangalore, and Hyderabad. In the last two towns, the growth has been primarily a result of the public sector undertakings located in them. The Department believes that a considerable momentum for further growth has already been generated in these areas and other efforts should now be made to push the electronics industry into the less-advanced areas and states in the country. It is, however, admitted that while electronics requires a minimum of infrastructural facilities such as water, power, roads, etc., it does require a good reservoir of manpower, both skilled and semiskilled. Hence, it may not always be possible to locate electronics units in a backward area or district; on the other hand, in many of the so-called backward areas, many traditional skills are available, which could well be utilized for the electronics industry.

In addition to the above, the Department has also been encouraging the identification of "growth centres" in each state, which would enable new units both in the organized and the small-scale sector to come into existence at such centres. To assist the state governments further in the matter, the Department announced in 1972 a scheme to grant Rs25 lakhs for the setting up of Testing and Development Centres on suitably located

Electronics Estates where a sizable number of units, particularly those in the small and medium sector, exist or are likely to come into existence. The state governments on their part are expected to provide land and buildings, roughly assessed at 25% of the total cost of setting up such centres. The operational expenses for funding the centres are also the responsibility of the state governments. The response of the states has been heartening. Such centres have already come into existence on the Vikram Sarabhai Estate set up at Adyar near Madras. Another centre is functioning at Baroda on the Electronics Estate at Makharpura. Similar centres are in the process of being set up in Calcutta, Kanpur, Punjab, Rajasthan, Andhra Pradesh, Kerala, U.P., and Himachal Pradesh. In Chandigarh and Ranchi, Electronics Estates are being set up that are devoted exclusively to instrumentation, which is relevant to the local demand and the skills available in that area. In this manner, there has been a widespread dispersal of the electronics industry throughout the country in the last few years.

The Electronics Commission has given considerable thought to the role of the large, medium, and small units in the further growth of the electronics industry. The production of electronics equipment, which is basically assembly operations, can be done in the small-scale sector with minimum overheads and infrastructure. It is for this reason that special encouragement was given to the production of TV receivers in the small-scale sector, and the success of some of the models made in that sector has proved that the scale of operations is no criterion for the ultimate success of such ventures. On the other hand, where the production process involves the utilization of automatic machinery, which determines the total capacity of the unit, it is felt that the small-scale sector may have a disadvantage compared with the large-scale one. Thus, in the production of electronic components it may become necessary for much larger volumes of production to be set up than is possible with the limitation of capital investment inherent in the small-scale sector. The Department has, therefore, been encouraging the further growth of the component industry in the medium- and large-scale sectors with a considerable amount of export orientation.

Another important aspect to which the Department has given considerable thought is the role of foreign companies in the growth of the electronics industry in India. In this connection, it may be pointed out that companies with substantial foreign equity ranging from 49% and above have played an important part in the spread of consumer electronics in the initial period. It is only in recent years that the emphasis has shifted in the electronics industry from purely consumer electronics items such as radio amplifiers to professional electronics and computers. Whereas in 1965-1966 consumer electronics represented as much as 60% of the total electronics items, in 1973-1974 it had dropped to around 25%. It is expected that in the Fifth Plan period, the main thrust for the further growth of electronics will be in the area of professional equipment and components as well as computers and industrial electronics.

It is possible to group the foreign companies operating in the electronics area into four broad categories:

(1) Those that are wholly owned by foreign companies or are subsidiary to them: The outstanding example in this category is IBM, whose Indian operations are controlled as a branch of the IBM World Trade Corporation with its headquarters in New York; similar is the case with ICL (Marketing) Ltd. A few other companies such as ASEA and ERICSSON are also in the same category, but these are comparatively small and operate in specialized fields.

(2) Companies in which the foreign companies have a majority equity participation: In this category are companies such as Siemens, Philips, English Electric, Gramophone Co., and International Computers (India) Manufacturers Ltd., in which the foreign equity percentage is around 60%. All these companies have played a significant role in one or another aspect of the electronics industry. For instance, Siemens has been prominent in the field of control equipment, Philips in consumer electronics and components, English Electric in instrumentation, Gramophone Company in the production of gramophone records, and International Computers (India) in the manufacture of computers and peripherals.

(3) Companies in which the foreign equity content is substantial but not in a majority (i.e., below 50%): These are companies such as Bush India and Murphy India, in both of which Rank-Xerox have a participation of 40% and less, as well as newer companies such as O/E/N with a participation of 45%.

(4) Companies in which the foreign equity content is comparatively small (i.e., less than 30%).

In the past few years, the Electronics Commission has been critically examining the role of the foreign companies in the future growth of the electronics industry. It has laid down two primary criteria in this regard: (a) obtaining significant technological gains through the operations of these companies, which are not otherwise easily obtainable, or if obtainable, only at a much higher cost; and (b) earning significant foreign exchange through export by these companies. The Commission is of the view that companies with high foreign equity should certainly be able to contribute to one or both of these aspects. Even where substantial exports are involved in areas of low technology, the Commission has felt it necessary to safeguard any possibility of such companies getting a foothold in areas normally barred to them. Where a particular item is reserved for the small-scale sector, there is an automatic imposition of export obligation of 75%. But even in cases where the item is not specifically reserved for the small-scale sector, substantial export obligations are being imposed on companies with high foreign equity to counteract the outflow of foreign exchange through dividends and royalties. It is also being ensured that since the exports are for a limited period of 5-10 years, the possible later adverse impact on the Indian domestic market should be counteracted and a potentially high-growth local market protected for the indigenous industry.

It is on the basis of these considerations that the Electronics Commission had taken major policy decisions in the last few years in regard to the further growth of foreign companies in areas that are considered "soft" from the technological point of view or that offer substantial scope for local entrepreneurs, particularly those who are technically oriented. In the television receiver industry, it was, therefore, decided that companies with substantial foreign equity such as Philips, Murphy, or Bush need not be given licences in view of the fact that their brand names are likely to inhibit any growth of the industry on purely indigenous lines. Again, in the field of electronic desk calculators, the licencing both in the organized and in the small-scale sector has been given primarily to indigenous companies and entrepreneurs. In both these areas, there has been a significant growth of local entrepreneurship in the last few years because of the fact that these areas have been virtually demarcated for indigenous industry rather than those in which foreign technology and brand names are likely to play an important part.

The Electronics Commission has also given careful thought to the possible future avenues of growth in regard to the foreign companies. It was considered that while on the one hand there is a need to protect the indigenous industry from the adverse impact of these companies, it should also be ensured that any such companies that have access to the latest technology as well as to marketing channels should be enabled to play their part in the growth of the electronics industry in India. This is particularly so in regard to export earning, where the companies producing items with internationally known brand names can find wide export markets all over the world. One has, therefore, to balance the outflow of foreign exchange due to dividends and royalties as well as the inhibiting impact of the foreign companies on the indigenous industry with the advantages of having access to new technology as well as to wide export markets.

The Electronics Commission had examined the role of IBM in the computer area in a series of discussions with the company. Based on these discussions, the Commission decided that IBM, which controls 60% of the total world market and 74% of the Indian market, cannot be allowed to continue on the basis of importing used machines and refurnishing them without at the same time being willing to dilute their foreign equity according to the guidelines laid down by the Government of India. It was, therefore, decided in 1971 that the manufacture of the 'AS-IS' machines had to be phased out and this is now being implemented.

On the other hand, it was felt that a company like IBM should take up the production of items on a 100% export basis. It is now manufacturing key punches (No. 129), which are resulting in significant exports for the country. Thus in 1972-1973, the export of such punches as well as unit record equipment was in the order of Rs182.56 lakhs, and in 1973-1974 exports amounted to Rs322.42 lakhs. It is expected that for some of these products, IBM will act as one of the key sources for export throughout the world.

In regard to the second category of companies, the Commission has been laying down specific policies after careful examination of the areas of strength of each of the companies. Thus in regard to Philips, a negotiating team was appointed in 1972 in which the Ministry of Industrial Development was also represented. Philips (India) was required to submit its program of future activities and these were then discussed with the company. Based on these discussions, the negotiating team submitted a report to the Department in June 1973, which was subsequently considered by the Electronics Commission. As a result of these discussions, all the pending applications that the company had made in the last 3 years have been processed and letters of intent recommended in specific cases. Further, in accordance with the recommendations made by the negotiating team, the Department of Electronics has taken the view that the company may be allowed substantial expansion or entry into the fields of professional components and equipment, for which there is likely to be a significant demand in the Fifth Plan period, as well as in areas where substantial exports are possible. One hundred percent of the export proposals for variable gan condensers, amplifiers, and intercommunication equipment have recently been cleared by the Cabinet Committee on the recommendation of the Licencing Committee. There will also be a substantial increase in the earnings of foreign exchange through exports of products made by Philips (India) to other countries where the principals of the company operate.

A similar exercise is also being attempted in regard to other companies in this category. Siemens, English Electric, and ICL are being advised to map out specific programs for producing equipment that is either technologically sophisticated or can be exported in considerable numbers. It is felt that as a result of this exercise these companies will play an important role in meeting the indigenous demand for items currently imported and also for undertaking exports of such items.

In the third category are all companies where the foreign equity content is substantial but not a majority, either numerically or in terms of the Foreign Exchange Regulations Act; thus Bush India has 40% equity and Murphy India 38% equity content in them. Both these companies have had a substantial share of the radio market for many years, but are now being advised to shift their operation to either technologically sophisticated products or significant exports. Bush India has been approved for the manufacture of pocket calculators and car radios with an export obligation as high as 90%. Murphy is also planning to manufacture items that are either meant for export or that are technologically more complex. Both these companies have developed, over the years, considerable expertise in marketing and management and the Department expects that this expertise will be utilized in tapping markets abroad, particularly in Western Europe and the United States.

In the last category are companies whose foreign equity is currently below 30%. The Department has consistently taken the stand that where indigenous know-how is available, it is not necessary for parties to obtain foreign collaboration except where such collaboration becomes useful either for introducing new technology or for undertaking substantial exports. Even in cases where collaboration is considered desirable, the Department, in accordance with the policy of the government, consistently advises parties to make payments of technical know-how fees and royalties according to approved norms rather than encourage investments by foreign collaborators. Where such investment, however, becomes absolutely necessary, it is being kept at as low a level as possible.

The electronics industry in India today is on the point of take-off and has a potentiality for high growth in the next few years. It is, therefore, necessary to examine critically the activities of all foreign companies in the field of electronics to determine the role that the government would like them to play in the development of the electronics industry in the country. The Department is also exercising vigilance so that foreign majority companies do not distort the structure of capital investment by Indian companies through the purchase of shares or through diversification into areas of trading or commercial activities that are likely to have an adverse impact on the growth of indigenous industry. For this purpose, the Department keeps in close touch with the Reserve Bank of India with a view to ensuring that the powers conferred on the Reserve Bank of India through the Foreign Exchange Regulations Act are utilized in a meaningful way. Broadly, the Department has taken the view that foreign companies may be allowed to continue operations (or even expand them) for the benefit of the country as a whole; but they cannot, and must not, be allowed to inhibit the growth of indigenous industry, particularly in the small and medium sector.

It may be mentioned that the electronics industry is basically low in investment but high in know-how requirements. What is needed as input from abroad is not so much foreign investment in terms of capital, but more in terms of technological know-how to keep pace with the changing trends of the industry in the advanced countries. Another important area in which know-how is essential to the growth of the industry is export marketing capability, particularly in the context of an acute shortage of electronic products in many parts of the world. Foreign companies can play a useful role in meeting the worldwide shortage of goods by producing some of these items in India and marketing them in the developed countries. The Department of Electronics keeps in close touch with the technology trends and markets abroad to see how the latest technology could best be brought into the country as well as how exports could be undertaken without at the same time being burdened with high equity investments.

Manpower and Employment

The electronics industry in India is poised for a major growth during the next decade. Rapid technological changes are leading to a requirement for manpower that should be highly skilled and more adaptable. The social changes, including changes in the education system, are altering the pattern of supply of human resources in ways that may not always be in tune with the technological requirements. To ensure that the supply of trained personnel matches the future demand, it is imperative to take up the problem of manpower planning on a priority basis.

A developing country's demand for highly qualified and skilled manpower is as important as the capital itself. To ensure that the lack of qualified personnel does not serve as a bottleneck in the growth of the industry, long-term projections regarding the requirement of these personnel need to be worked out and training programs initiated to meet the future demand.

When planning for manpower, knowledge of labour productivity is essential. Labour productivity can be considered as a set of technical coefficients, which in effect establish connections between the output of different sectors of an industry and the most important resource labour. It is, in the most general sense, volume of income per employed person. When employment cannot be increased substantially or can be increased only in the long run, the economic development will depend on productivity increases. This is the case with many developed countries. The situation is rather different in the case of developing countries like India, which have vast amounts of human resources and where the production in labour-intensive industries, like the electronics industry for example, can be increased through substantial increases in employment. It is, however, not always advisable to maintain a low level of productivity and raise the production, only by an increase in employment. This may affect the healthy growth of the industry.

It is possible to estimate the manpower requirements for any industry, provided the future targets for production are set. However, additional information regarding the trends in productivity, the level of technology being used, and the existing policies in its industrial development is also essential. A certain level of technology, and hence of productivity, is represented by a specific kind of organization and a specific kind of capital equipment that is made to work by the labour force. The skill composition of this labour force is also fairly well defined. Management of organization and control of production, for example, are the main tasks of administrative, scientific, technical, and other highly qualified personnel. From the production point of view, the skill requirements of the workers in any industry are of the following three types: skilled, semi-skilled, and unskilled. The relative proportion of each of these groups of employees in an industry depends on the techniques being adopted for production in the various sectors.

The Bhabha Committee envisaged that the average wage bill for producing electronics equipment would be 38% of the sale value, of which the wage bill for those engaged in direct production, engineering supervision, design, and development in the plant would be about 28%, while the wage bill for auxiliary staff engaged in stores, purchasing, and administration would be about 10%. The output per person employed for the manufacture of equipment in the electronics industry, including all supporting and auxiliary staff, was estimated to be Rs9,000 against Rs12,000 for a person directly employed in production. As the Committee envisaged a production of Rs300 crores worth of electronics equipment by 1975, the total manpower requirement was projected to be 330,000, with the skilled workers, technical staff, and engineers numbering 250,000.

For the production of Rs300 crores worth of equipment, the production of roughly Rs84 crores worth of components was envisaged. The output per person employed in the components and other process-oriented industries was assumed to be about double that for the equipment industry. On this basis the total number of persons employed in the components production industry in 1975 was estimated to be about 40,000, with skilled workers and technical engineers numbering about 32,000. An additional manpower force consisting of about 15,000 scientists and engineers and 30,000 supporting technical staff was envisaged for research and development activities in laboratories and research institutes outside the plants.

Thus it was expected that an investment of Rs170 crores would provide employment in the electronics industry for some 400,000 scientists, engineers, skilled workers, and supporting staff, the per capita investment being about Rs4,000. Although to a large extent India has achieved the production targets set by the Bhabha Committee, this is not the case as far as the manpower employment in the industry is concerned. It is estimated that at present about 120,000 persons are engaged as production and supporting staff. This is only about 30% of the projected figure. The main reason for the Bhabha Committee's estimates going astray is the increase in per capita productivity. At present the average per capita productivity for the electronics equipment industry is about Rs30,000, while for components industry it is approximately Rs15,000.

The increase in employment during the Sixth Plan period is expected to be less than the corresponding increase in the output because per capita productivity is expected to increase further as a result of improvements in production techniques. The partial growth of mechanization and automation of assembly line operations, the increased use of integrated circuit technology, and the associated miniaturization will reduce the demand for semiskilled workers to some extent. The employment of engineers, scientists, skilled workers, and administrative staff is expected to increase.

VENEZUELA

(The Capital Goods Industry)

The primary purpose of this section is to analyze Venezuela's capital goods industry and the national market. Secondly, a specific analysis of the technological problems in the capital goods industry is attempted, including its significance in the national scientific and technological systems.

The relevance of the capital goods sector to the country's technological situation is seen in the influence of the type of product on the technological processes of production. If the capital goods are imported or if the technology to produce them in the country is imported, not only are the supply and prices of these goods affected but also their quality, utilization, characteristics, etc., and those of the goods and services obtained through them.

The Development of the Capital Goods Industry in Venezuela

a) The Establishment of the Capital Goods Industry: Because of the economic policies adopted and the economic structure predominant in Venezuela in different institutional periods, the capital goods industry has been relegated to a secondary place. The growth of consumer and intermediate goods production has been greater in the model observed, causing the relative retarding of the production of capital goods.

This model, based on an import substitution policy, delays development of the sector until there is an advanced production of agricultural and industrial consumer goods and of intermediate products; these products would then create a capital goods market in the country. Until such an advanced production exists, however, these goods must be imported from developed nations with whom economic, commercial, and political ties are maintained. In correspondence with the above, it is found that a low percentage of the potential production of the manufacturing industry is assigned to this sector: only 4% of the manufacturing employment, which is nearly 10,000 workers, in some 223 establishments, only 3.5% of the total; and 2.7% of the subscribed capital, which represents about Bs215,000,000. To this base of production is added a collection of handicraft establishments, which include manufacture and repair and which are not registered in the Industrial Survey of Venezuela but in the Registry or Directory of D.G.E. Establishments (annual).

Retardation and External Dependence of the Sector: In this phase of its development, the capital goods industry consists of assembly, as the production of pieces, parts, and accessories is less important than that of finished products and the proportion of imported goods is 47% of the value of the nonfactory costs.

The technicians and engineers, or the administrative personnel responsible for the activities of technological research, adaptation, and development, represent only 3.4% of the total personnel in these industries, while in countries such as Brazil the proportion is (at least apparently) 32.5%, a figure ten times that of Venezuela's.

Importance of Small Industries: An even participation exists between small and medium industries and large industry in this sector, in terms of the quantity of the work force as well as in terms of value-added capital.

It can be expected that as the sector develops, it will be dominated by small and medium firms; the proportion of these strata in the sector is already much greater than that of the other manufacturing industries. Small industries produce basically unserialed goods and generally have higher technological requirements, and they have less participation by transnational enterprises.

Government Enterprises: The participation of the government as entrepreneur within the sector has so far been limited to dry docks for naval repairs and to telephones, but there are plans for participation in the naval and aeronautics industries as well as in tractors and other farm machinery. The advance of the capital goods industry is closely tied to decisions on government investment, which now can rely on greater financial backing to satisfy the requirements of these enterprises. It is justifiable to conclude that, because of this fact and because the government is an important customer of capital goods, important sector areas must be reserved for direct investments.

Productivity: The productivity of employed personnel - according to the indicator Gross Added Value/Labour - in general terms of branch strata is similar among the different branches, with the exception of the large industry of electrical appliances and apparatuses, whose Bs56,000 per person annually is the highest of all the other branches in the sector.

With this exception, it can be affirmed that there is no difference in the productivity per person between large industry and the other strata, nor within the different branches and subsectors. An extreme case, but of less relevance, is that in the area of transport materials, which shows markedly less productivity than the other branches of the sector, with Bs14,000 per person annually.

b) Needs and Feasibility of the Development of Industry and Capital Goods: On this level an examination of the capital goods market in Venezuela is important to make some observations about its influence on the developmental possibilities of this industry.

Capital goods are the durable goods of production, making their demand dependent on the demand for consumer goods and the replacement, repair, and expansion of the existing supply.

In Venezuela there is a set of structural and economic policy characteristics that give incentives to the demand for machinery, equipment, and tools of the imported type, there being no spontaneous or promoted stimuli for increasing the internal demand for national capital goods or the technological development of internal production. At first view, these factors are as follows: the exchange rate, which is overvalued and favours all imported articles; the abundance of foreign currencies, which favours the purchase of equipment in any quantity at any price from any country; the policy of almost total exoneration of import controls on the importation of capital goods from abroad; and, an indiscriminate policy of credit for financing the purchase of capital goods, be these national or not. Connected to this last point, there is no purchasing policy on the part of the government that favours national demand for national equipment.

Lack of Standardization of the Market and Its Inelasticity: The demand for machinery and equipment and their respective parts is marked by heterogeneity as to models and brands acquired, producing the absence of standardization, which handicaps national production. The high price inelasticity of the demand for capital goods and especially for spare parts is another noticeable trait of the market. The machinery and equipment have very little competition as far as the quality of labour is concerned in sectors such as industry and transport and, though to a much lower degree, in agriculture and construction. Added to this poor substitution power of the market is a situation of control of supply on the level of commercial dealers or direct producers. This situation goes far in explaining the inflationary tendency in the price of imported capital goods. On the level of importers, great benefits are received through the elevated margin of commercialization. To this must be added the costs of installation and initial functioning of much equipment. In most cases, world producers place a product through intermediaries and subsidiaries in a given country, who assure the supply of parts and other services to clients, including credit (loans, leasing, leasing with purchase options), and obtain extraordinary profits. It has been affirmed that, especially in recent years, the export prices of these goods to oil-producing countries are much higher than normal export prices and normal internal prices.

Because replacement parts are tied to the types, brands, and models of corresponding capital goods, their speculative components are greater than the machinery and equipment themselves. This can be seen in the fact that the price per unit of weight of imported parts is greater than that for the original equipment and machinery.

Sectoral Composition and Growth of Demand: The most important group of capital goods as to quantity of demand is that of machinery, accessories, and tools for industry and agriculture, which corresponds to 67% of the FOB import prices for capital goods in 1968 and an even greater percentage, 75%, in 1972. Within this group, that which corresponds to capital goods for the manufacturing industry has the highest revenue, 50% of the imported capital goods in 1968 and 59% in 1971 (FOB). It is in this category, i.e., machinery for manufacturing, that the heterogeneity, technological complexity, and speculative margin have the greatest relevance in an average period. An indicator such as that of prices (FOB) per imported kilo reveals that this is 150% of the corresponding figure for agriculture.

The machinery and equipment for agriculture and for the industries of construction and electrical power have, as favourable characteristics, less heterogeneity and generally less-complicated technology. Together these make up an important fraction of the market, offering the most favourable field for the substitution of imports in an integrated manner. The demand for these three sectors encompasses a group that, according to 1971 figures, represents nearly one-third of the total imports of capital goods in the country, in terms of FOB prices.

The increase in the demand for capital goods is high, with a tendency toward growth in recent years due to the increase in prices and to factors that pressure demand for capital goods in general and for imported goods especially.

Elements Favourable for National Production: A key element for marketing feasibility is economic integration: regional and subregional. Given that the majority of the product lines that make up the sector are exigent in regard to the minimal scale of production - on the level of standardization - this necessitates the design of production from its beginnings to the supply of the internal market as well as the export market. The comparative advantages of the capital goods industry in terms of costs and commercialization must be seen together with a normalizing process, which also guarantees competition on the basis of quality.

Venezuela's financial potential allows the sector to provide internal financial backing for costly investments, to cover the costs of research and technological adaptation, and to finance production through proper mechanisms. This financial potential, especially that of the government, is an advantage for the economic development of the sector, which most countries of the Third World do not possess.

Another important comparative advantage is the availability of raw materials and intermediate products in regard to adequate quantity, quality, and price offered by the basic metal industries in which the government is shareholder or owner.

Although the consumption of steel in Venezuela is currently greater than its production, this situation has been provided for through Plan IV of SIDOR. In this way, additional supplies of raw material will be available, to which must be added the production contemplated in private metallurgical projects.

Steel plans also include variations in the quality of national steel supplies, introducing certain alloys and laminations, which is a great boom to the sector's industry. The principal steel products that make up part of the capital goods industry would be part of internal production; these are laminated steel, steel plating, hoops, tubing, tensioned steel, wire (all refined and carbon-processed steel), and cast-iron and wrought-iron pieces.

Of the remaining types of raw materials such as nonferrous metals (aluminum, tin, copper), metals for special alloys (vanadium, chromium, etc.), and plastics, these are most easily acquired or produced internally. Similarly, so are materials for soldering, woods, paints, and cables. The special alloys should preferentially be imported.

The development planned for the automobile industry (by CORDIPLAN and the Industrial Planning Board) represents an additional basis for the economic and technological development of the sector. The establishments dedicated to a certain type of production in this field, especially those of machinery, motor foundries, axles, and gear-boxes, can eventually turn to the production of parts and finished products in the capital goods sector. The quality-control activities designed for the automobile industry, as well as those of research and selection-adaptation, can extend themselves to capital goods. In this way the automotive industry would not be competitive in regard to capital goods, but rather complementary.

Scientific and Technological Aspects Associated with the Capital Goods Sector

Technological development of the capital goods sector is marked by two fundamental characteristics:

(1) Production by industry in this sector is on an inadequate technological level in regard to the internal demand for capital goods.

(2) The technology used by established capital goods industries is mainly external in origin and involves expensive conditions, with no real transfer of technology because of the weak or nonexistent local scientific and technological infrastructures.

In the judgment of suppliers, there exists free access to the capital goods manufacturers in producer countries, so that there are no limitations in this respect on local industry in obtaining the most recent technological advances in production equipment. However, there are sufficient reasons of economic competition for clients and manufacturers to place obstacles on the more or less immediate market of goods carrying very important innovations. National industry has been challenged to confront the accelerated technological innovations in capital goods or to confine itself to sectors with slower innovations in products, leaving to imports those goods with higher technological requirements.

In regard to the technology of established enterprises, a first limitation for their technological development is a high proportion of foreign investment, which controls many important businesses and in some cases covers 60% of the subscribed capital and resists local technological development. In the second place, there is in national enterprises a tendency similar to the behaviour of foreign enterprises in importing goods without actually appropriating foreign technological advancements.

When national enterprises come in contact with the bearers of technology, the weaker the infrastructure and local technological capacity, the less disposed the suppliers are to offer their technology, or, if they do, they demand subservience.

Technological research within the sector is carried out in several institutions. There is no single institute or centre specifically oriented toward research on machinery and equipment or toward specific subsectors. In IVIC, some teams have been sporadically developed, especially for medical use and biomedical research, which are important technological advances, and in CANTV, research is being done on measurement and communication instruments. Most of the innovations in this sense have been preferentially achieved by the client industries, but many of them have been neither registered, protected, nor utilized.

The commercial enterprises that are the principal channels for introducing imported equipment are not controlled by any technological requirements incorporated in the equipment they sell. In most cases involving the government, including the Ministry of Defence, national purchases of equipment are channeled through these companies. In only a few cases do clients buy directly from a foreign manufacturer or from a foreign commercial agent outside their own country, in areas where the manufacturers with the greatest operational volume exist. In this sense, these home or affiliate offices act as one more client in Venezuela's market, with the prerogatives given them by the volume of sales they carry out and their capacity to pay. Since commercial activity is so profitable in this sector, it is these enterprises, and not the factories, that are the most attractive centres for national and foreign capital. This is reinforced by the exclusivity that many manufacturers give to their representatives in client countries.

The commercial dealers absorb most of the importation commerce of capital goods, because they offer their clients and the purchasers of their brands facilities in regard to rapidity of the sale of parts, installation services (when these are necessary) and functioning services (initial operation), as well as repairs, maintenance, and restitution.

In this way, clients will remain interested in a commercial dealer and not deal directly with the manufacturer or home office outside their country - even though they pay a higher price in the first case - because they obtain these additional advantages, which they probably would not have if they bought directly and not through a commercial dealer.

On the other hand, commercial dealers have ample access to the media, so that with knowledge of the needs and preferences of consumers, they can orient them toward making certain decisions in regard to brands, durability, and capacities of the equipment, its versatility, energy requirements, etc. In general, these commercial dealers induce clients toward the technological advancements of their equipment or provide them with their own programs for the renovation of their machinery.

The dealers, at the same time, can serve as channels for disposing of used equipment, sometimes rebuilding it or preparing it for resale to clients with less economic potential or those less likely to accept innovation, whether of the same type of industry or not.

Table 1: Age of Firms.

Age in Years	Percentage	Number of Firms
Over 20	36.8	24
Between 10 and 20	35.4	23
Between 5 and 10	13.9	9
Between 0 and 4	13.9	9

Source: Sectoral Survey, DGFM.

Table 2: Units Produced by Size of Firms.

Persons Employed	Size	Number of Firms (%)	Units	%	Weight (tons)	%	Amount $	%
Over 45	-large	12.8	1,736	12.7	7,626	59.0	12,150	53.8
20 - 45	-medium	21.3	4,233	31.0	2,936	22.7	5,583	26.8
6 - 19	-small	43.5	6,813	50.0	2,135	16.5	3,962	17.6
0 - 5	-very small	22.4	853	6.3	225	1.8	413	1.8

Source: Sectoral Survey, DFGM.

Table 3: Innovations and Innovating Firms.

Year	Innovating Firms	Innovation	Firms Currently Using Innovation
1955	A	Aging of the foundries	A-B
1958	A-D-E	Gearings produced by profile-generating methods	A-B-C-D-E
1958	A-D	Thermically treated gearings	A-D-G
1958	A	High-precision, adjustable cylindrical roller bearings	
1960	A	Tempering and rectification of bedframes	A-B-C
1960	A	Temperable, pearlitic foundry	A
1960	A	Use of high-precision roller bearings	A-B-C
1960	D	Adjustable nuts with balancing and elimination of clearance	A-F-C-H
1962	I	Pneumatic drive couplings	I Several
1962	J	Electropneumatic drive couplings	I-J-K Several
1964	K	Electropneumatic clutches and brakes	Several
1965	A	Development of copying hydraulics	Several
1965	C	Systems of lubrication and friction elimination by oil fog and cushion	C
1965	A	Reversing slotted shafts thermically treated and with rectified slots	A-D
1965	A	In high-production lathes, bedframe developed on vertical or sloped plane to facilitate cuttings evacuation	A
1965	A	Adjustable nuts with constant tension	A-D-C
1966	A	Forged gearings	A
1967	C	Lubrication by oil fog in closed milieu	C
1967	A	Forged and thermically treated spindles	A
1968	C	Use of self-braking motors	C
1969	C	Use of preloaded bearings	C
1970	A	Demountable guides of tempered and rectified steel	A
1970	A-C	Frequent use of preadjusted tools	A-C
1971	C	Lubrication by oil fog in leakproof milieu, with recirculation	C
1971	L	Hydropneumatic drive coupling	L

NOTES

(1) Estudio A. Spilzinger, Study of the machine tools market, Revista Equipamiento, April 1971.

(2) The estimates of the present sample are in agreement for 1975. The importance of this piece of data lies in the fact that the distributors of national machine tools are at the same time importers of foreign machine tools, which places them in a position such that they must evaluate the advantages of a greater import substitution, with the resulting decrease in their profits as importers. As an example, one might mention that three of the leading firms of the sector are directly dependent on the most prominent importer of machine tools, a firm owned by Swiss capital.

(3) United Nations Industrial Development Organization, Regional Seminar on Machine Tools in Developing Countries of Europe and the Middle East, Notes on the economics of the machine tool industry, presented by the Unione Construttori Italiani Macchine Utensili (ID/WG. 87/30), 6 October 1971, p. 1.

(4) Concerning the role of immigrants in early Brazilian industrialization, see, for instance, W. Dean, The industrialization of Sao Paulo, 1880-1945, Austin, University of Texas Press, 1969, especially ch. 4.

(5) See N.H. Leff, The Brazilian capital goods industry, 1929-1964, Cambridge, Mass., Harvard University Press, 1968, ch. 4.

(6) For a description and analysis of the exchange policy of the period, see C. Furtado, Fermacao economica do Brazil, Rio de Janeiro, 1959, ch. 34; D. Huddle, Balance de pagamentos e controle de cambio no Brazil: Diretrizes politicas e historia, 1946-1954, Revista Brasileira de Economia, XVIII, No. 1, March 1964.

(7) W. Baer, Industrialization and economic development in Brazil, Homewood, Irwin, 1965, p. 75.

Appendix 1
INSTITUTES AND COUNTRIES PARTICIPATING IN THE STPI PROJECT

Argentina	Secretaria Ejecutiva del Consejo Latinoamericano de Ciencias Sociales (CLACSO) Country Coordinator: Eduardo Amadeo
Brazil	Financiadora de Estudos e Projetos (FINEP) Country Coordinator: Fabio Erber (until September 1974) and José Tavares
Colombia	Fondo Colombiano de Investigaciones Cientificas y Proyectos Especiales "Francisco José de Caldas" (COLCIENCIAS) Country Coordinator: Fernando Chaparro
Egypt	Academy of Scientific Research and Technology Country Coordinator: Adel Sabet (until July 1975) and Ahmed Gamal Abdel Samie
India	National Committee on Science and Technology Country Coordinator: Anil Malhotra (until June 1975) and S.K. Subramanian (until March 1976)
South Korea	The Korea Advanced Institute of Science (KAIS) Country Coordinator: KunMo Chung
Mexico	El Colegio de Mexico Country Coordinator: Alejandro Nadal
Peru	Instituto Nacional de Planificacion (INP) Country Coordinator: Enrique Estremadoyro (until February 1975) and Fernando Otero Technical Directors: Fernando Gonzales Vigil (until February 1975) and Roberto Wangeman
Venezuela	Consejo Nacional de Investigaciones Cientificas y Tecnologicas (CONICIT) Country Coordinator: Dulce de Uzcategui (until July 1974) and Ignacio Avalos
Yugoslavia (Macedonia)	Faculty of Economics, University of Skopje Country Coordinator: Nikola Kljusev

Appendix 2
SURVEY OF THE COUNTRY TEAM'S WORK

The organization, composition, and orientation of each of the country teams reflected the own interests and those of the institutions that hosted them, always within the framework of the STPI project concerns. A brief review of the approach and the work of each team may help to place the STPI project and the comparative reports in perspective. To complete the survey, a description of the field coordinator's office work is given.

ARGENTINA: The initial location for the Argentine team was the Department of Economics of the Catholic University. However, after some months, the university decided to withdraw its application and the country coordinator moved to the Argentine branch of the executive secretariat of the Latin American Social Science Council (CLACSO). The team was headed by Eduardo Amadeo, an economist, and two other members were appointed to work full time on the project. An advisory committee of several researchers and policymakers active in science and technology policy was formed. To carry out the research, the team relied on consultants who wrote reports on specific subjects that were integrated into a final report.

A significant change took place when the country coordinator was named president of the Instituto Nacional de Tecnologia Industrial (INTI), the national industrial technology institute, which is the largest and most important industrial research organization in Argentina. Mr Amadeo never relinquished his formal role as coordinator; after 6 months, he left his new post and resumed his position as country coordinator. Because most of the work was well under way, his absence did not substantially alter the team's pace, although the preparation of the Argentine synthesis report was postponed. Part of the team's work was reoriented to be most useful to the coordinator in his new position.

The Argentines focused on two branches of industry - machine tools and petrochemicals - but studied many broader issues. For instance, the reports include a document on the technological content of the 3-year development plan (1974-77), a study of the Argentine industrial structure, a description and brief analysis of technology policy instruments in Argentina, a study of the system for regulating technology imports, and several short reports on international technical assistance as an instrument of technology policy.

The structure of the Argentine scientific and technological system was studied in detail, as were the conditions under which it could be made more responsive to industry's needs. The Argentines covered the public sector, examining the possible role of the public sector as promoter of scientific and technological development. Detailed studies were carried out at two enterprises: one in charge of generating electricity in Buenos Aires (SEGBA) and the other in charge of generating and distributing gas for household and industrial consumption. Other contributions of the Argentine team were a study of the emergence and development of engineering and consulting firms in the chemical process industries, a detailed analysis of two research centres within the national industrial technology institute (INTI), and two short papers on capital accumulation and on the crisis of capitalism.

The Argentine team followed the methods guidelines; however, they produced a series of thematic reports on issues of actual and potential interest to policymakers in the country, coinciding with the themes selected for study in STPI.

BRAZIL: The Brazilian team was hosted at the research group of the Financiadora de Estudos e Projetos (FINEP), the state agency in charge of financing studies for investment projects and also the executive arm of the national fund for scientific and technological development. The first coordinator was the director of the research group, Fabio Erber. When he took a leave of absence from FINEP in September 1974, he was replaced by José Tavares, the new head of the research group. The group at FINEP had been carrying out research on science and technology policy for some time, and the STPI assignment was one of its tasks for 1973-76. Practically all of the work was done by members of the FINEP research group, although two or three reports were contracted to professionals outside FINEP.

From the beginning, the Brazilians decided to concentrate on the role of state enterprises in technology policy. They chose branches of industry that were dominated by state enterprises (oil and petrochemicals, steel, and electricity), conducting detailed interviews, analyzing existing data, and testing hypotheses systematically to cover issues such as the selection of equipment and processes, the purchase of engineering services, the performance of research and development, and the planning activities at these state enterprises.

In addition to the new material generated by the Brazilian team during STPI, several reports based on past research carried out by FINEP were made available to the STPI network. These included background reports on the organization and structure of the Brazilian science and technology system, a study on the machine tool industry, a report on the demand for services of 12 research institutes, and a background report on industrial policies in Brazil during the last 2 decades.

In parallel with the work for STPI, the FINEP team was also engaged in a research project on the diffusion of technical innovations in three industrial branches (pulp and paper, cement, and textiles) and they agreed to put their results at the disposal of the STPI network as an additional contribution.

The Brazilian team used the guidelines only as a general reference, given that most of their work went along different lines from those originally envisaged for the project. Nevertheless, the richness and variety of their material effectively upgraded the comparative reports.

<u>COLOMBIA</u>: No Colombian participant was present at the initial organizing meeting, and the Colombian application to join the STPI network was received later and formally accepted at the Rio meeting of the coordinating committee. The team was hosted by the Colombian Council for Science and Technology, COLCIENCIAS, and was headed by a sociologist, Fernando Chaparro. In spite of joining the STPI network late, the Colombian team caught up with the pace of work and finished all its work by the deadline.

COLCIENCIAS organized a special team with five members who devoted practically all their time to research in STPI. Several other consultants were also asked to prepare reports on issues of specific interest such as selected policy instruments. For example, a study was commissioned on the impact of tariff mechanisms; a report was prepared on the influence of price controls; and a preliminary analysis of the possible use of the state's purchasing power as an instrument of technology policy was also prepared. The branches chosen for study were all linked to agriculture: fertilizers and pesticides, agricultural machinery, and food processing, taking into consideration the interests of Colombian policymakers as perceived by the team. In these branch studies, the methods guidelines were closely followed.

Other reports prepared by the Colombian team include a study of science and technology planning, an analysis of implicit industrial technology policies, a conceptual framework for the study of consulting and engineering organizations, a series of reports on industrial branches based on discussions with panels of experts, a study of science and technology policies in the agricultural sector (to complement the analysis done for industry), and two essays on the process of industrialization in Colombia and its technological implications.

Five groups of policy instruments were studied in detail, and their impact on each branch was examined through interviews at various enterprises. All of the findings were integrated into the final report of the Colombian team.

<u>EGYPT</u>: Although an Egyptian representative participated in the initial deliberations leading to the STPI project, it was not possible to organize the team to carry out

research and prepare inputs for the international comparison. There were several administrative difficulties and staffing problems that prevented the organization of a working team. The host institution was the Academy of Scientific Research and Technology and the first coordinator was Adel Sabet, who was replaced by Gamal A. Samie in July 1975. The Egyptian team presented papers that were personal contributions based on past experience rather than the result of research carried out by a team; and research was not begun at the academy until the second half of 1976.

INDIA: The host organization in India was the National Committee on Science and Technology, and the first coordinator was Anil Malhotra, who was replaced in June 1975 by S.K. Subramanian. Mr Subramanian resigned in March 1976, and no one replaced him. No funds were requested to set up a country team in India, and the Indians provided background material that had already been collected as background for a new science and technology plan.

Three background documents were distributed along with the final S & T plan to all the teams in STPI. In addition, a report on foreign collaboration, a note on science and technology planning in India, a survey of engineering consultancy services, a report on the development of the electronics industry, and two papers on small-scale industries and technology transfer were distributed by the Indian coordinator. No empirical research was done following the methods guidelines, and the Indian contribution to the comparative reports reflects this.

SOUTH KOREA: The South Korean team was one of the first to be organized and was estalished at the Korean Advanced Institute of Science, KAIS, as part of the activities of its science, technology, and society program. KunMo Chung was named country coordinator and the team consisted of five other members. All but one of them had other academic duties and could allocate only a portion of their time to STPI research. Then, Graham Jones was hired to advise in the preparation of the report for phase 1.

The South Korean team advanced rapidly and completed its work in time for the Sussex workshop, following the methods guidelines and introducing modifications only where necessary. Two reports were produced corresponding to the requirements for phases 1 and 2 of the project.

The branches chosen for study were electronics, petrochemicals, and powder metallurgy, and a report was prepared for each one. In addition, the team prepared documents on engineering services and industrialization in South Korea, on the Korean Institute of Science and Technology, on transfer of technology in the electronics industry, on the interface between the science and technology plan and the economic development plan, and on state enterprises in technical development.

Although most of the work was done by the team located at KAIS, consultants were asked to deal with specifics. The team predominantly represented engineering and physical sciences, but an economist who was a senior government official, helped to relate the results to South Korean policymakers and to balance the other team members' biases.

MEXICO: The Mexican team was among the first to start working in STPI and was located at El Colegio de Mexico, an academic and social research and graduate training organization. Alejandro Nadal was country coordinator and there were four other members of the team who worked full time on STPI. The Mexican team initially followed the guidelines rather closely and was one of the first in suggesting modifications and changes as a result of contrasting concepts with preliminary research findings. In particular, the team found it difficult to interpret the results of interviews in enterprises using the schema proposed to study technological behaviour. The branches chosen for detailed study were capital goods, food processing, and petrochemicals.

A background report on the structure and evolution of the Mexican scientific and technological system was prepared, together with a description of the industrialization process and of agricultural development. Documents on particular subjects included a report on engineering firms, a study of the technology policy of PEMEX (the state oil monopoly), and progress reports dealing with hypotheses on the impact of policy instruments on technical behaviour at the enterprise level, a description of policy instruments in Mexico, etc.

Most of the findings of the Mexican team were integrated into the main final report, part of which was delivered at the coordinating committee in New Delhi (January 1976) and the rest at the Sussex workshop (June 1976). The work of the Mexican team covered practically all the research topics considered in STPI, and its contribution to the comparative report reflects this. The Mexican report was published in Spanish in 1977 and was awarded second prize in a contest for the best works in economics.

For various reasons, the Mexican team chose to limit its direct interaction with policymakers and followed its own research program. Results were made available to policymakers in the form of draft reports, and through the participation of the coordinator in one of the committees established to prepare the Mexican plan for science and technology.

PERU: The Peruvian team was established within the research group of the National Planning Institute. A series of administrative difficulties affected the progress of the team, including a change of technical director, when Fernando Gonzales Vigil was replaced by Roberto Wangeman in February 1975. Approximately two-thirds of the research was completed in time for the Sussex workshop.

From the beginning, the team decided to adopt a sectorial approach to the research. Efforts were focused on the study of industrial branches connected with the extraction and processing of minerals and with the provision of machinery for the mining industry. The steel industry was also studied, with emphasis on the state enterprise in charge of the largest steelworks. This meant that the guidelines were used primarily in sectorial studies and in the analysis of policy instruments.

Background reports on the situation of the scientific and technological system and on the evolution of Peruvian industry were prepared following the general framework put forward in the guidelines. In addition to these and the sectorial reports, the team prepared other documents, dealing with issues such as explicit and implicit science and technology policies, consulting and engineering capabilities, the possible use of state enterprises as instruments of technology, and the governement administrative machinery for science and technology policy.

The Peruvian team was located within an official government organization, but its direct impact on policymaking is difficult to assess because it took the form of daily contact with government officials. On the basis of the sectorial reports on mining, a committee has been set up to review the findings of the STPI team.

VENEZUELA: The Venezuelan team was hosted by the national council of science and technology (CONICIT) and was among the first to start working. The team was initially dominated by sociologists, although economists increased their participation at later stages. The first coordinator, Dulce de Uzcategui, was replaced by Luis Matos, who was soon followed by Ignacio Avalos. Three other members worked full time, and the team was biased toward sociology and economics.

They progressed through two stages punctuated by a change in government. In the first stage, most of the background reports corresponding to phases 1 and 2 of the STPI methods were prepared, covering the science and technology, the political, the educational, and the economic systems. These reports were made obsolete by the change in government. In the second stage, the team tried to adjust to the new situation, repeating some of the earlier studies and continuing the research. However, the organization of a national congress on science and technology, which mobilized all the staff working at CONICIT, affected the team's progress.

The branches chosen for study were capital goods, electronics, and petrochemicals. In addition, reports were written on specific issues such as the governement organizational structure for science and technology policy, instruments for industrial science and technology policy, economic and financial policy instruments and their impact on technology, the purchase of capital goods in two industrial branches, and the relations between the financial system and technology policy. The Venezuelan team concluded its research shortly after the Sussex workshop.

The fact that the Venezuelan team was located in a government agency that took a very active role in science and technology policy after the change in government created both opportunities and problems. As a result of the new tasks undertaken by CONICIT, the pace and continuity of the STPI work was frequently altered. On the other hand, there was more possibility for actively contributing to policymaking. The Venezuelan contribution to the comparative reports reflects this situation.

YUGOSLAVIA (MACEDONIA): The Macedonian team was organized at the faculty of economics of the University of Skopje. A senior faculty member, Nikola Kljusev, was appointed coordinator. The team was composed of a very large number of faculty members and researchers who devoted part of their time to STPI. The tasks were subdivided and individual reports requested from various members of the team, although at a later stage two team members were asked to work full time on STPI.

The Macedonian team did not follow the guidelines, except in the preparation of a background report for phase 1. Individual reports were submitted on issues of interest to the STPI network, covering topics such as the problems of research and development in industrial enterprises, aspects of science and technology policy in Yugoslavia, the metallurgical industry in Macedonia, and the growth of engineering firms in Yugoslavia.

The Macedonian team's specificity is reflected in their relatively limited contribution to the comparative reports. At any rate, given the high degree of participation of professionals at all levels in policymaking in the Yugoslav self-managed economy, it is rather difficult to assess their contribution toward policymaking in conventional terms.

THE FIELD COORDINATOR'S OFFICE: In August 1973, at the first meeting of the coordinating committee, Francisco Sagasti was appointed field coordinator of the project and his office was established shortly thereafter and began operating in a limited way. Staffing was completed in April 1974 with the addition of two members.

The field coordinator's office was independent from the teams and was not engaged directly in empirical research. It offered organizational and technical support and contracted consultants to prepare reports on topics defined by the coordinating committee.

The field coordinator, first, drew up methods guidelines for phases 1 and 2 of the project. Background reports on technology policy in China, on technological dependence/self-reliance, on science and technology planning, on technology policies in Japan, and on technology transfer were also prepared, either by staff members of the field coordinator's office or by consultants. The guidelines for phases 3 and 4 of the project were prepared jointly by the field coordinator and a consultant. The office also organized the Sussex workshop and drafted the comparative reports. The field coordinator was also active in the board of the Peruvian Industrial Technology Institute (ITINTEC).

With the exception of the teams that were engaged in science and technology policy research as part of the activities of their institutions (the Brazilian and South Korean teams, for example), the teams were dismantled after the STPI project was completed. The field coordinator's office was closed in December 1976, and the comparative reports were prepared during 1977-1978, although some teams had not finished their work by April 1978. Even though most teams had concluded their STPI activities by the end of 1977, this does not mean that the team members left the field of S & T policy research and that their effort in STPI was not followed up. What was dismantled, as planned from the beginning, was the formal structure of the STPI project. The network of personal contacts remains in operation and most of the former team members are active in the field of science and technology policy, carrying the experience accumulated in STPI to their new positions.

Key to STPI Publications

STPI

Primary

(1) The STPI Project
(2) Methodological Guidelines
(3) Main Comparative Report
(4) Planning
(5) Chinese Technology Policy/ Industrialization

Modules

(6) S&T: Differing Schools of Thought
(7) Evolution of Industry
(8) Evolution of S&T
(9) S&T - Present Status
(10) Policy & Generation of Technology
(11) Policy for Imports
(12) Policy for Technology Demand
(13) Policy to Promote Industrial S&T
(14) Policy for Industrial S&T Support
(15) Industrial Technical Changes
(16) Industrial Technology Behaviour
(17) Technical Change Studies

Selections

(18) S&T Policy & Development
(19) Engineering Consulting & Design in LDCs
(20) Technology Transfer in LDCs
(21) State Enterprises & Technological Development

Background Papers

(22) El INTI en la Industria Argentina
(23) El Sector Maquinas Herramientas en la Argentina
(24) Los Instrumentos de Politica Cientifica y Tecnologica en Argentina
(25) Brazilian Machine-Tool Industry
(26) Los Bancos y Comercializacion de Tecnologia
(27) La Industria Petroquimica
(28) La Variable Tecnologica y las Variables Horizontales
(29) Indian Electronics Industry

Country Papers

(30) Mexico
(31) Korea
(32) Peru
(33) Colombia

A GUIDE TO THE SCIENCE AND TECHNOLOGY POLICY INSTRUMENTS (STPI) PUBLICATIONS

A. Primary Publications

(1) The Science and Technology Policy Instruments (STPI) Project (IDRC-050e) (out of print)

(2) Science and Technology Policy Implementation in Less-Developed Countries: Methodological Guidelines for the STPI Project (IDRC-067e) (out of print)

(3) Science and Technology for Development: Main Comparative Report of the STPI Project (IDRC-109e). (Also available in French (IDRC-109f) and Spanish (IDRC-109s).)

(4) Science and Technology for Development: Planning in STPI Countries (IDRC-133e)

(5) Science and Technology for Development: Technology Policy and Industrialization in the People's Republic of China (IDRC-130e)

B. Modules

These constitute the third part of (3) above and provide supporting material for the findings described and the assertions made in (3).

(6) STPI Module 1: A Review of Schools of Thought on Science, Technology, Development, and Technical Change (IDRC-TS18e)

(7) STPI Module 2: The Evolution of Industry in STPI Countries (IDRC-TS19e)

(8) STPI Module 3: The Evolution of Science and Technology in STPI Countries (IDRC-TS20e)

(9) STPI Module 4: The Present Situation of Science and Technology in the STPI Countries (IDRC-TS22e)

(10) STPI Module 5: Policy Instruments to Build up an Infrastructure for the Generation of Technology (IDRC-TS26e)

(11) STPI Module 6: Policy Instruments for the Regulation of Technology Imports (IDRC-TS33e)

(12) STPI Module 7: Policy Instruments to Define the Pattern of Demand for Technology (IDRC-TS27e)

(13) STPI Module 8: Policy Instruments to Promote the Performance of S and T Activities in Industrial Enterprises (IDRC-TS28e)

(14) STPI Module 9: Policy Instruments for the Support of Industrial Science and Technology Activities (IDRC-TS29e)

(15) STPI Module 10: Technical Changes in Industrial Branches (IDRC-TS31e)

(16) STPI Module 11: Technology Behaviour of Industrial Enterprises (IDRC-TS32e)

(17) STPI Module 12: Case Studies on Technical Change (IDRC-TS34e)

C. Selections

These are a selection of the numerous reports prepared for the STPI Project chosen as a representative sample of the various topics covered by the STPI Project in the course of the main research effort on policy design and implementation.

Science and Technology for Development: A Selection of Background Papers for the Main Comparative Report.

(18) Part A: Science and Technology Policy and Development (IDRC-MR21)

(19) Part B: Consulting and Design Engineering Capabilities in Developing Countries (IDRC-MR22)

(20) Part C: Technology Transfer in Developing Countries (IDRC-MR23)

(21) Part D: State Enterprises and Technological Development (IDRC-MR24)

D. Background Papers

(22) El INTI y el Desarrollo Tecnologico en la Industria Argentina (In press)

(23) El Sector Maquinas Herramientas en la Argentina (In press)

(24) Los Instrumentos de Politica Cientifica y Tecnologica en Argentina (In press)

(25) The Brazilian Machine-Tool Industry: Patterns of Technological Transfer and the Role of the Government (In press)

(26) Rol de los Bancos en la Comercializacion de Tecnologia (In press)

(27) Comportamiento Tecnologico de las Empresas Mixtas en la Industria Petroquimica (In press)

(28) Interrelacion Entre la Variable Tecnologica y las Variables Horizontales: Comercio Exterior, Financiamiento e Inversion (In press)

(29) A Planned Approach for the Growth of the Electronics Industry — A Case Study for India (In press)

E. Country Reports

(30) Instruments of Science and Technology Policy in Mexico (In press)

(31) Technology and Industrial Development in Korea (In press)

(32) Los Instrumentos de Politica Cientifica y Tecnologica en el Peru: Sintesis Final (In press)

(33) STPI Country Report for Colombia (In press)